Federal Greenhouse Gas Accounting and Reporting Guidance

Technical Support Document for Recommendations to the Council on Environmental Quality on Section 9 of Executive Order 13514

DO NOT QUOTE OR CITE

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Acronyms and Abbreviations

BOD	Biochemical Oxygen Demand
CAS	Chemical Abstract Service
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CHP	Combined Heat and Power
CH_4	Methane
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DOC	Degradable Organic Carbon
DoD	Department of Defense
DOE	Department of Energy
EERE	Energy Efficiency and Renewable Energy
eGRID	Emissions & Generation Resource Integrated Database
EISA	Energy Independence and Security Act
EO	Executive Order
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
EPCRA	Emergency Planning and Community Right-To-Know Act
F-gas	Fluorinated Gas (HFCs, PFCs, SF_6)
FAST	Federal Automotive Statistical Tool
FEMP	Federal Energy Management Program
FY	Fiscal Year
GE	Goal-Excluded
GHG	Greenhouse Gas
GS	Goal-Subject
GSA	General Services Administration
GWP	Global Warming Potential
HFC	Hydrofluorocarbon Group of Gases
HHV	Higher Heating Value
HVAC	Heating, Ventilation and Air Conditioning

ICFPA	International Council of Forest and Paper Associations
IPCC	Intergovernmental Panel on Climate Change
LandGEM	Landfill Gas Emission Model
LFG	Landfill Gas
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gases
MRR	EPA's Greenhouse Gas Mandatory Reporting Rule
MSDS	Material Safety Data Sheet
MSW	Municipal Solid Waste
MT CO_2e	metric tons CO_2e
NMOC	Non-Methane Organic Compounds
NF_3	Nitrogen Trifluoride
N_2O	Nitrous Oxide
ODS	Ozone Depleting Substance
OFEE	Office of the Federal Environmental Executive
PFC	Perfluorocarbon Group of Gases
PNR	Passenger Name Record
POC	Point-of-Contact
REC	Renewable Energy Certificate
SF_6	Sulfur Hexafluoride
LGO Protocol	*Local Government Operations Protocol*
T&D	Transmission and Distribution
TSD	*Technical Support Document for Federal GHG Accounting and Reporting Guidance*
VE	Vehicles and Equipment
WBCSD	World Business Council for Sustainable Development
WTE	Waste-to-Energy
WRI	World Resources Institute
WWTP	Wastewater Treatment Plant

1.0 Introduction

On October 5, 2009, President Obama signed Executive Order (EO) 13514 (74 *Federal Register* 52117) to establish an integrated strategy for sustainability throughout the Federal government and to make reduction of greenhouse gas (GHG) emissions a priority for Federal agencies. Among other provisions, EO 13514 requires agencies to "measure, report, and reduce their greenhouse gas emissions from direct and indirect activities." Section 9 of EO 13514 directs the Department of Energy's (DOE) Federal Energy Management Program (FEMP)—in coordination with the Environmental Protection Agency (EPA), Department of Defense (DoD), General Services Administration (GSA), Department of the Interior, Department of Commerce, and other agencies as appropriate—to develop recommended Federal GHG reporting and accounting procedures. DOE submits the recommended GHG reporting and accounting procedures as a draft guidance document. Under Section 9, the Council on Environmental Quality (CEQ), in coordination with the Office of Management and Budget (OMB), will issue the final guidance for agencies to use in carrying out their GHG accounting and reporting obligations.

1.1. Purpose of this Guidance

The *Federal Greenhouse Gas Accounting and Reporting Guidance* (or Guidance) establishes government-wide requirements to assist Federal agencies in calculating and reporting GHG emissions associated with agency operations. By following the Guidance and its subsequent revisions, individual agencies, and the entire Federal government, will be better able to consistently track progress against GHG reduction goals. **This technical support document (TSD) supplements the main Guidance document with detailed information on the inventory reporting process, reporting requirements, and accepted calculation methodologies**.

The Guidance is not designed for quantifying the reductions from individual GHG mitigation projects, nor does it include strategies for reducing GHG emissions.[1]

1.2. Overview of the Technical Support Document

The remaining chapters of the TSD cover the following topics:

Chapter 2: Reporting GHG Emissions

- Outlines the Federal GHG reporting approach and the GHG Reporting Portal.
- Describes the qualitative information that agencies must report.
- Summarizes the required and optional quantitative information for reporting.
- Summarizes the use of emission factors used throughout the TSD.

Appendix A: Calculating Scope 1 Emissions

- Establishes the "default" and "advanced" methodologies and data inputs for calculating scope 1 emissions.

[1] The only emission reduction strategy discussed is the use of renewable energy purchases, including renewable energy credits (RECs), because of their unique GHG accounting and reporting issues.

Appendix B: Calculating Scope 2 Emissions

- Establishes the "default" and "advanced" methodologies and data inputs for calculating scope 2 emissions.

Appendix C: Calculating Scope 3 Emissions

- Establishes the "default" and "advanced" methodologies and data inputs for calculating specified scope 3 emissions.

Appendix D: Emission and Conversion Factors

- Provides emission and conversion factors used in the calculation of scope 1, 2, and 3 emissions

2.0 Reporting GHG Emissions

This chapter summarizes the GHG reporting process, qualitative and quantitative data requirements, and use of emission factors in this TSD. It is supported by appendices that provide the methodologies and emission factors necessary to calculate agencies' GHG inventory.

2.1. Reporting Process

The reporting process is covered in detail in Chapter 5 of the main Guidance document. Key elements related to the rest of this TSD, including the electronic GHG Reporting Portal and the reporting approach, are reiterated below.

Electronic GHG Reporting Portal

Section 9(b) of EO 13514 requires DOE, in coordination with other agencies, to provide the necessary electronic reporting capability so that agencies can report their GHG inventories in a consistent and accurate manner. This reporting capability, or GHG Reporting Portal, will be operational by October 5, 2010, as required by EO 13514. FEMP will host and maintain the electronic GHG Reporting Portal and make it freely available for agency use. Agencies must use this reporting portal to submit their GHG inventories.

The GHG Reporting Portal will accurately represent current GHG reporting requirements and **provide GHG calculation functionality for the default data described below and in Chapter 2.3**. The GHG Reporting Portal will be updated with any new reporting requirements and methodologies concurrently with the guidance. Current FEMP energy reporting will be integrated into the GHG Reporting Portal to reduce the reporting burden for agencies. Data residing in the Federal Automotive Statistical Tool (FAST) system will automatically be transferred to the GHG Reporting Portal, and FEMP will work to enable data sharing with other relevant Federal data systems. Agencies will have the ability to review this imported data within the GHG Reporting Portal.

FEMP will provide training and other support tools to facilitate agency access to the GHG Reporting Portal. FEMP will also provide a spreadsheet-based data entry and calculation aid to assist with the preparation of the GHG report. Agencies may also choose to utilize this aid for facility-level GHG calculation and planning efforts.

Reporting Approach

Emission reporting is categorized as **required** or **optional**, as summarized in Chapter 2 of the main Guidance document. Each of the required categories has a calculation methodology that allows entry of "**default**" data into the GHG Reporting Portal. If using the default methodology, agencies must input activity-level data, some of which can be leveraged from existing programs and collection systems (such as the FEMP Energy Report and FAST system). Calculation methodologies and emission factors are embedded into the GHG Reporting Portal and will automatically calculate GHG emissions associated with the reported activity data.

For many emission categories, "**advanced**" methodologies—which can provide more accurate GHG accounting—are also available. Agencies may report using these advanced methodologies *instead* of the default methodologies, but their use is not required. As agencies become more familiar with GHG reporting, they are encouraged to utilize the advanced methodologies to increase the accuracy of their inventories. To the greatest extent feasible, the GHG Reporting Portal will also automatically calculate emissions on the basis of the type of activity data required to use the advanced methodologies. If the portal does not provide this function for an advanced methodology, agencies will need to calculate the emissions and then enter the quantities of each type of GHG emitted in units of metric tons.

For required emission categories, agencies must report using either the default or advanced methodology. As noted in Chapter 2 of the main Guidance document, there are also "optional" reporting categories, including some scope 3 emissions and specified land-use and agricultural emissions. The GHG Reporting Portal will not automatically calculate emissions from these categories based on entered activity-level data due to the data and methodological variability of these source categories. Agencies electing to report emissions for these optional categories will need to calculate the emissions and then enter the quantities of each GHG emitted in metric tons.

Advanced Calculation Example: On-Site Landfill

To illustrate how a detailed methodology might be used, consider an agency that manages a total of five landfills at different facilities, all of which are monitored and reported as part of the facilities' Clean Air Act (CAA) Title V permits. The agency's GHG lead works with each facility's air program manager to determine the site-specific variables for each landfill that are readily available. During this process, the agency determines that the landfills have been closed for several decades and emit lower amounts of CH_4 than reflected when using the scope 1 default methodology. Given that the data are available, the agency GHG lead decides to use the advanced GHG calculation methodology to calculate each of the five landfill's emissions and to report the total metric tons of CH_4 emissions under the Solid Waste/Landfill emission category in the GHG Reporting Portal.

2.2. Reporting Qualitative Content

The GHG report content can be broken down into qualitative and quantitative emissions inventory data. This section includes the qualitative information that agencies must report through the GHG Reporting Portal. These requirements are summarized in Table 2-1 and explained below.

Table 2-1: GHG Inventory Qualitative Reporting Requirements

Qualitative Reporting Category	Required Information
Agency Reporting Points of Contact (POCs)	• Agency • POC information of agency staff responsible for the GHG inventory
Reporting Period Information	• Fiscal year • Number of employees, on-site contractors, and/or visitors • Number of square feet for goal-subject (GS) and goal-excluded (GE) buildings[2]
Allowable Exclusions from the Target[3]	• Emission sources excluded from the target • Justification for excluded emissions
Inventory Calculations for Current Reporting Year	• Emission categories inventoried • Data sources and uncertainty in data quality • Tools and calculation methodologies used, if applicable
Changes in GHG Inventory	• Description of changes since prior reporting period • Anticipated future changes in inventory
Verification and Validation	• Description of verification and validation procedures completed • Inventory management plan, if available • Known or potential double-counting • Second- or third-party verifier, if applicable
Other Information	• Other information as necessary to explain report

Agency Reporting POC

Each agency's senior sustainability officer is ultimately responsible for submitting the agency GHG inventory and certifying its accuracy. However, the agency reporting POCs are designated agency staff responsible for addressing general and technical questions regarding the agency's GHG inventory.

Reporting Period Information

Identify the fiscal year of the data reported. Agencies will report how many employees, on-site contractors, and/or visitors they have to facilitate data analysis and normalization. These data may also be necessary, depending on which calculation methodologies an agency chooses to adopt. Facility square footage data, which is already reported for energy reporting, will likewise facilitate data normalization and analysis.

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[2] Given the intent of combined energy and GHG reporting, this required information aligns with existing FEMP Energy Report guidance on the determination of energy GS and GE buildings. This includes leased space where the agency directly pays for the utilities. Further information on determination of GE buildings can be accessed at www1.eere.energy.gov/femp/pdfs/exclusion_criteria.pdf.

[3] These are emissions excluded from GHG targets; they are not exempted from comprehensive inventory reporting requirements.

Allowable Exclusions from the Target

If an agency chooses to exclude emissions from its reduction target, it must justify this decision. Agencies must report these excluded emission sources separately in the GHG Reporting Portal, as even target-excluded emissions must be included in the comprehensive GHG inventory. If an agency receives approval from CEQ to exempt certain activities from provisions in the EO, the emissions from the exempt activities are not required to be inventoried. Agencies must indicate whether the determination of excluded emissions has changed since previous reporting periods.

Inventory Calculations for Current Reporting Year

For each emissions category, the agency must describe the following:

- Whether the emissions category is excluded or exempted
- Sources of data used
- Any uncertainty in data quality, including potential errors or omissions in the data[4]
- Any additional tools or methodologies utilized for advanced methodology or optional reporting.

Changes in GHG Inventory

Agencies must include the degree to which the following potential changes from the prior reporting year have impacted their inventory, and should explain the key reasons for these changes:[5]

1. Changes in calculation or estimation methods: Where an agency chooses to use an advanced methodology, it must indicate which one it applied. Because any changes in methodology from year to year can affect the accuracy of the emissions estimate, the agency must indicate whenever calculation methodologies change and estimate the impact of that change. If an agency wants to employ a different methodology from that stipulated in the main Guidance document or this TSD, the agency must first discuss it with CEQ. Note that estimation method changes may require base year and intervening year recalculations as stipulated in item 3 below.
2. Changes in organizational boundary: Describe how the list of exclusions and exemptions reported, as well as other factors, may have changed the agency's organizational boundary. Note that organizational boundary changes may require base year and intervening year recalculations as stipulated in item 3 below.
3. Base year and subsequent year recalculation: Summarize changes in base year and subsequent year calculations (see Chapter 5.4 of the main Guidance document for more information). Agencies may also describe how any adjustments to emission factors,

[4] Both the utility and accuracy of a GHG emissions report depend on the quality of the data available. Agencies should give particular attention to any data problems, including missing data, means used to evaluate data quality, and procedures used to ensure data accuracy.
[5] For FY 2010 reporting, agencies should compare to their FY 2008 inventory, where applicable.

especially Emissions and Generation Resource Integrated Database (eGRID) output emission rates, affected their past inventories.

4. Other changes in emissions: Agencies may summarize other changes in emissions that did not trigger a base year recalculation.
5. Anticipated changes for next reporting period: Indicate any known or anticipated changes in organizational boundaries in future years that may affect the inventory. For instance, long-term or temporary planned changes in an agency's mission or operations may significantly impact GHG emissions. Agencies should report such changes to the extent they consider them relevant to understanding the high-level summary and trends of emissions reported.

Verification and Validation

Agencies must discuss their approach for verification and validation, and whether any change is foreseen in this approach for the next reporting year. Agencies can reference a separate inventory management plan, if applicable. Agencies should also acknowledge any known or potential double-counting within their inventory. If an agency used second- or third-party verification, the verifier's contact information must be listed. See Chapter 6 of the main Guidance document for more information on verification and validation.

2.3. Quantitative Inventory Data Requirements

Agencies must report activity data inputs and/or GHG emissions for each emissions category through the GHG Reporting Portal. This section lists the default data elements for reporting scope 1, 2, and 3 emissions and emissions reported outside of the scopes (such as biogenic). Data reported by the agency must be summed to the highest level within the agency to encompass all operating units.

Agencies must maintain records of the underlying data inputs that feed into the agency-level GHG inventory. The GHG Reporting Portal will maintain records for each year reported, including the chosen GHG methodology (default or advanced) for each year and the resulting GHG emissions. The sum of CO_2e emissions will be calculated automatically by the GHG Reporting Portal for each emissions category and maintained over time.

Required Scope 1 Data

Agencies must report scope 1 emissions in four major categories: stationary combustion, mobile combustion, fugitive emissions, and process emissions. Agencies that do not have any process emissions must provide a positive statement that emissions in that category do not apply to them.

Stationary and Mobile Combustion

All agency scope 1 stationary and mobile combustion emissions data must be reported in units as indicated in the "Default Data" column of Table 2-2. The GHG Reporting Portal will calculate GHG emissions for each GHG and the total metric tons CO_2e (MT CO_2e) from each of the

reported data elements in the default methodology. Agencies must report the fuel use and total of each GHG emitted if using the advanced method for mobile sources.[6] Because agencies will also be using the GHG Reporting Portal for FEMP energy reporting, they must report emissions from goal-subject (GS) energy, goal-excluded (GE) energy, non-fleet vehicles and equipment (VE), and fleet vehicles separately, according to the definitions previously established under the Energy Policy Act (EPAct) of 2005, EO 13423, and the Energy Independence and Security Act (EISA).

Table 2-2: Data Needed for Required Reporting: Scope 1 Emissions from Stationary and Mobile Combustion

Emissions Category	Default Data	Current Reporting	Advanced Methodology Available?
Stationary Combustion (agency-owned and -controlled heat and steam)	• GS and GE for natural gas • Volume [KCUFT] or energy content [BBtu]	• FEMP Energy Report[7]	No
	• GS and GE for fuel oil, gasoline, and liquefied petroleum gases (LPG)/propane • Volume [KGal] or energy content [BBtu]	• FEMP Energy Report	No
	• GS and GE for coal and other municipal solid waste (MSW) • Mass [short tons] or energy content [BBtu]	• FEMP Energy Report	No
	• GS and GE for biofuels and biomass • Volume [KCUFT or KGal], mass [short tons], and/or energy content [BBtu]	• FEMP Energy Report	No
Mobile Fossil Fuel (agency-owned and -controlled vehicles, airplanes, etc.)	• Fleet and VE for compressed natural gas (CNG), gasoline, diesel, LPG/propane, aviation gas, jet fuel, navy special, and other • Gasoline Gallon Equivalent [GGE], Volume [KGal or KCUFT], and/or energy content [BBtu]	• FAST system • FEMP Energy Report	Yes
	• Fleet and VE for ethanol and biodiesel blends, such as E85, biodiesel (B20), and biodiesel (B100) • Biofuel content (such as % ethanol) • Volume [KGal] or energy content [BBtu]	• FAST system • FEMP Energy Report	Yes

[6] For each category using an advanced method, agencies will report the energy activity data and the calculated total quantity of CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 in metric tons, respectively.

[7] For consistency with existing FEMP Energy Report guidance, scope 1 and 2 categories utilizing the energy-related activity data in their native energy reporting units (e.g., Thousand Cubic Feet [KCUFT], Billion Btu [BBtu], Thousand Gallons[KGal], etc.) rather than more common units (e.g., [SCF], [MMBtu], [Gal], etc.).

Fugitive Emissions

All agency scope 1 fugitive emissions data must be reported in units as indicated in the "Default Data" column of Table 2-3. The GHG Reporting Portal will calculate GHG emissions for each type of GHG and the total MT CO_2e from each of the reported data elements in the default methodology. If advanced methodologies are used, the agency scope 1 fugitive emissions must be reported in MT for each GHG emitted. The GHG Reporting Portal will convert these emissions into total MT CO_2e.

Table 2-3: Data Needed for Required Reporting: Scope 1 Fugitive Emissions

Emissions Category	Default Data	Current Reporting	Advanced Methodology Available?
Fluorinated Gases (F-gases): hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), SF_6	• Mixed refrigerant and/or F-gas material type • Amount charged or issued [lb] • Amount returned to the supply system, including recovered from equipment [lb]	• Facility Title VI reporting materials • Procurement records • Facility hazardous material management	Yes
On-Site Wastewater Treatment	• Population served (includes employees, on-site contractors, and visitors)	• Facility human resource records • Facility security records	Yes
On-Site Landfill/Municipal Solid Waste	• Landfill open date • Landfill close date • Total mass of MSW disposed on-site [short tons]	• Facility Title V reporting materials • EOs 13423 and 13514 solid waste and diversion reporting	Yes
Others	• Agency- and facility-specific data required	• Facility Title V, Mandatory Reporting Rule (MRR), and/or Emergency Planning and Community Right-To-Know Act (EPCRA) reporting	Yes

Process Emissions

All agency scope 1 process emissions must be reported in MT for each GHG type emitted. The GHG Reporting Portal will convert these emissions into total MT CO_2e. There are no default methodologies for process emissions because they are site- and/or process-specific. Instead, Appendix A.8 lists methodology references for specific types of process emissions. If agencies have process emissions to which the list of methodology references does not apply, they may consult with CEQ to identify an appropriate methodology.

Some agencies may find that supporting data on their process emissions are already used to prepare their reports under the CAA Title V, EPA's Greenhouse Gas MRR, EPCRA 313 (Toxic Release Inventory), and other programs. Agencies are encouraged to leverage data directly from their existing regulatory compliance data collection and calculation efforts, as appropriate.

Required Scope 2 Data

Agencies must report emissions in five major categories: purchased electricity, purchased steam, purchased hot water or chilled water, purchased combined heat and power, and waste-to-energy purchased steam. When reporting combined heat and power, agencies must use the appropriate method, which depends on whether it purchased electricity, steam, and/or hot water. All agency scope 2 emissions data must be reported in units as indicated in the "Default Data" column of Table 2-4.

Table 2-4: Data Needed for Required Reporting: Scope 2 Emissions

Emissions Category	Default Data	Current Reporting	Advanced Methodology Available?
Purchased Electricity	• GS and GE electricity consumed [MWh] by eGRID subregion and U.S Territory	• FEMP Energy Report*	No
Purchased Steam, Hot Water, or Chilled Water	• Steam and hot water consumed [BBtu] • Cooling demand [BBtu or Ton Hours]	• FEMP Energy Report	Yes
Combined Heating and Power	• GS and GE electricity consumed [MWh] by eGRID subregion • Steam or hot water consumption [BBtu]	• FEMP Energy Report†	Yes
Purchased Steam from Waste to Energy	• Steam consumed [BBtu] • Default eGRID derived emission factors	• FEMP Energy Report	Yes
Renewable Energy Purchases and REC Purchases	• Renewable energy, or RECs, purchased [MWh] • eGRID subregions in which the renewable energy was generated • Generator on- or off-agency site and whether on the agency side of meter, separately metered, or off grid	• FEMP Energy Report†	No

*Requires new level of disaggregated data for eGRID subregion.
†Requires new source location information for eGRID subregion level.

Agencies must track and report the requisite data separately for each calculation methodology.[8] **For purchased electricity, data must be reported separately for each eGRID subregion,** and emissions will be calculated by the GHG Reporting Portal using the most recent eGRID subregion output emission rate factors. Because agencies will also be using the GHG Reporting Portal for FEMP energy reporting, they must report GS and GE energy separately according to the definitions previously established under EPAct 2005, EO 13423, and EISA.

FEMP will use the same data classifications as existing Federal energy reporting to the extent possible. If agencies utilize the default category, the GHG Reporting Portal will use the reported activity data to automatically calculate emissions for each of the six respective types of GHGs separately and express the total in MT CO_2e. Otherwise, the data entered into the advanced methodology categories should consist of both the energy used and the MT for each GHG emitted.

Renewable Energy and RECs

Agencies must separately report purchased renewable energy, including renewable energy certificates (RECs) that are being applied to reduce agency scope 2 electricity use. Reporting must be consistent with existing renewable energy guidance and Chapter 4 of the main Guidance document. Agencies must provide the following information related to all RECs purchased:

1. Source/type
2. Location or eGRID subregion of the energy generation project producing the REC
3. Amount of renewable energy associated with the REC [MWh or BBtu]
4. If the generator is on-site, identification of whether the generator is on the agency side of the meter, separately metered, or off-grid.

The eGRID subregion non-baseload output emission rate factors will be embedded in the GHG Reporting Portal, so the total MT CO_2e of each REC purchased will be automatically calculated.

Required FY 2010 Scope 3 Data

Agencies must report three emissions categories: business air travel (employees only), T&D losses from purchased electricity, and contracted solid waste disposal (employees only). All agency scope 3 emissions data must be reported in units as indicated in the "Default Data" column of Table 2-5.

For business air travel, agencies must coordinate with GSA and their travel agent to ensure data are reported into the GSA Travel MIS tool (see Appendix C.4 for additional detail). T&D losses from purchased electricity will be automatically calculated in the GHG Reporting Portal because emissions are based on the emission factors for scope 2 data already submitted. For contracted

[8] Agencies that produce power for facilities collocated with power production facilities may develop their own emission factors. This allowance recognizes that agencies in this situation would require a unique determination of transmission and distribution (T&D) losses. FEMP will work with agencies in these situations to avoid double counting.

solid waste, the default methodology in the GHG Reporting Portal will use the tons disposed of and the default values provided in Appendix C.3.1. Agencies may alternatively coordinate with their waste contractors for site-specific emission factors. If using the advanced methodologies, agencies must report scope 3 emissions in MT for each GHG type emitted.

Table 2-5: Data Needed for FY 2010 Required Reporting: Scope 3 Emissions

Emissions Category	Default Data	Current Reporting	Advanced Methodology Available?
Federal Employee Business Air Travel	• Passenger Name Record (PNR) from Travel Agent sent to GSA	• PNRs currently submitted to GSA • Agency Travel Reporting	No
T&D Losses	• Purchased electricity [MWh] by eGRID subregion	• FEMP Energy Report	No
Contracted Municipal Solid Waste Disposal	• Municipal solid waste disposed [short tons]	• EO 13423 & EO 13514 Solid Waste and Diversion Reporting	Yes

Required FY 2011 Scope 3 Reporting

For FY 2011 reporting, agencies must also report scope 3 emissions for ground business travel, employee commuting, and contracted wastewater treatment (see Appendix C). In FY 2011, facilities operated under private-sector and GSA leases will also be required to report scope 3 emissions, but the development of that methodology is still pending. Although not required for FY 2010 reporting, agencies are encouraged to report and reduce these scope 3 emissions, especially if baseline data are available. See Chapter 2.2.3 of the main Guidance document for more information.

For ground business travel (such as rail, bus, and/or rental vehicle), agencies should coordinate with their travel agents and accounting departments to determine data availability (Table 2-6). Information on commuter travel can come from national or regional travel survey data for the default category or through agency- or site-specific commuter surveys using the advanced methodology. Agencies should coordinate with their facilities to investigate the availability of commuter data and/or existing surveys. For contracted wastewater treatment, the GHG Reporting Portal will use the number of employees served and the default values provided in Appendix C for the default methodology. Agencies may alternatively coordinate with their facility-level providers for the variables necessary to calculate advanced emission estimates.

Table 2-6: Data Needed for FY 2011 Required Reporting: Scope 3 Emissions

Emissions Category	Default Data	Advanced Methodology Available?
Federal Employee Business Ground Travel	• Mode of transportation • Distance-traveled data, in miles	Yes
Federal Employee Commuting	• Frequency of commute • Average one-way distance traveled by employee per day • Percentage modes of transport used by employees (such as personal vehicle, train, bus)	Yes
Contracted Wastewater Treatment	• Number of employees served	Yes

Optional Scope 3 Reporting

Agencies may report additional scope 3 emissions resulting from unique activities for which this Guidance provides no methodologies. Examples of such activities associated with land management agencies include the following:

- Visitors to Federal sites (such as National Parks)
- Third-party oil, gas, and coal mine leasing activities
- Enteric fermentation, involving releases by livestock not owned by an agency, occurring but on Federal land[9]
- Manure management systems operated by others on Federal land.[10]

To the extent possible, agencies should use methodologies that are commonly accepted. This approach will ensure consistent calculations if those emission categories require reporting in future years. If an agency reports emissions in a category where no commonly accepted methodology is available, it must document and submit the calculation methodologies used as part of its annual inventory via the GHG Reporting Portal. Agencies should coordinate with FEMP on the methodologies proposed for all scope 3 categories if they differ from the default or advanced methodologies. All agency scope 3 emissions must be reported in MT for each GHG type emitted.

Emissions Reported Outside of the Scopes

Required Biogenic Emissions Reporting

[9] If the animals in question are owned by the Federal agency, these emissions are optionally reported as scope 1.
[10] If these systems are owned or controlled by the agency, the emissions may be optionally reported as scope 1.

As discussed in Chapter 3 of the main Guidance document, biogenic emissions are accounted for separately from scope 1, 2, and 3. Biogenic CO_2 emissions are generated during the combustion of biofuels and biomass. Agencies are required to report the biogenic CO_2 emissions generated by these combustion activities, where data are available. Because biogenic CO_2 emissions must be reported separately from the scopes, they do not count against GHG reduction targets at this time.

The GHG Reporting Portal will automatically calculate scope 1 emissions from biogenic sources (CH_4 and N_2O from the entire biofuel blend and CO_2 from the fossil fuel portion of biofuel blends) on the basis of an agency's reported biogenic renewable energy use.[11] Agencies using advanced methodologies should ensure they calculate and report biogenic emissions in those categories, as applicable.

Optional Other Reporting Outside of the Scopes

In addition, agencies may separately report outside of the scopes types of GHGs that are not covered by the EO. For example, agencies may optionally report non-covered GHGs with high global warming potentials, such as nitrogen trifluoride (NF_3). Agencies may also report use of ozone depleting substances (ODSs), which are often replaced with PFCs and HFCs.[12] These are reported separately from biogenic emissions. FEMP will provide functionality in the GHG Reporting Portal to support optional reporting.

2.4. Emission and Conversion Factors

To ensure accurate GHG inventories, appropriate emission and conversion factors must be applied consistently across the government. This section describes the factors used in the default calculation methodologies. As necessary, this document will be revised by September 30 of each reporting year to incorporate the most accurate calculation methodologies and emission factors available.

Emission Factor and Calculation Methodology Selection

Emission factors and methodologies referenced in this document were selected because of their applicability to Federal operations, technical authority, and acceptance in other GHG reporting programs. The calculation methods and emission factors were leveraged from existing GHG regulatory and voluntary inventory protocols, with the EPA MRR given top priority when applicable, followed by other Federal sources. Emission factors and methodologies were selected from the following sources:

1. EPA, *Mandatory Greenhouse Gas Reporting Rule (MRR), Federal Register*, October 30, 2009, see www.epa.gov/climatechange/emissions/ghgrulemaking.html.
2. EPA, *Climate Leaders Program, Technical Guidance*, see www.epa.gov/stateply/resources/index.html.

[11] Biogenic emission calculation methodologies are provided in Appendix A.2.
[12] Federal agencies choosing to report ODSs or NF_3 fugitive emissions should utilize the applicable methodology in Appendix A.5.

3. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, see www.epa.gov/climatechange/emissions/usinventoryreport.html.
4. EPA, *eGRID Technical Support Document, Chapter 3*, see www.epa.gov/egrid.
5. DOE, *1605(b) Voluntary Reporting of Greenhouse Gases Program, Technical Guidelines*, see www.eia.doe.gov/oiaf/1605/gdlins.html, www.eia.doe.gov/oiaf/1605/ggrpt/index.html, and www.eia.doe.gov/oiaf/1605/emission_factors.html.
6. EIA, *Emissions of Greenhouse Gases in the United States*, Documentation and Emission Factors, see www.eia.doe.gov/oiaf/1605/ggrpt/documentation/pdf/0638%282006%29.pdf and www.eia.doe.gov/environment.html.
7. International Panel on Climate Change (IPCC), *2006 Guidelines for National Greenhouse Gas Inventories*, see www.ipcc-nggip.iges.or.jp/public/2006gl/vol1.html.

Emission and Conversion Factor Sources

Table 2-7 summarizes emission and conversion factor sources used throughout this TSD:

Table 2-7: Emission and Conversion Factor Sources

Applicable Scope	Emissions Categories	Factor Type	Default Methodology Emission Factor Source	Emission Factor Applies to Advanced Methodology?
All scopes and optional	All emission categories	Global warming potentials	EPA MRR, Table A-1 to Subpart A of Part 98	Yes
		Conversion factors	EPA MRR, Table A-2 to Subpart A of Part 98	Yes
Scope 1 and biogenic	Stationary combustion (agency-owned and -controlled heat and steam)	CO_2 emission factors and HHVs for various types of fuel	EPA MRR, Table C-1 to Subpart C of Part 98	Yes
		CH_4 and N_2O emission factors for various types of fuel	EPA MRR, Table C-1 to Subpart C of Part 98	Equipment-specific
	Mobile combustion (agency-owned and -controlled vehicles, airplanes, etc.)	CO_2 emission factors and HHVs for various types of fuel	EPA MRR, Table C-1 to Subpart C of Part 98	Yes
		CH_4 and N_2O emission factors for various types of fuel	EPA MRR, Table C-1 to Subpart C of Part 98	Vehicle-specific
Scopes 1 and 3	Landfill/MSW	Emission model equation defaults	EPA MRR, Table HH-1 to Subpart H of Part 98 and LandGEM	Yes, site-specific*

Applicable Scope	Emissions Categories	Factor Type	Default Methodology Emission Factor Source	Emission Factor Applies to Advanced Methodology?
	Wastewater treatment	CH_4 emission factors/model	EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks	Yes, site-specific*
Scope 2	Purchased electricity	CO_2, CH_4 and N_2O emission factors by eGRID subregion	EPA, eGRID Output Emission Rate Summary Tables and DOE 1605(b) Emission Factors	N/A
	Purchased steam or hot water	CO_2, CH_4 and N_2O emission factors	DOE 1605(b), Technical Guidelines	No, plant-specific†
	Chilled water	CO_2, CH_4 and N_2O emission factors	DOE 1605(b), Technical Guidelines	No, plant-specific†
	Combined heating and power	Electricity, steam, and hot water CO_2, CH_4 and N_2O emission factors	EPA, eGRID Output Emission Rate Summary Tables and DOE 1605(b), Technical Guidelines	No, plant-specific†
	Purchased steam from waste-to-energy	Steam CO_2, CH_4 and N_2O emission factors	EPA, eGRID Derived	No, Plant-Specific†
	Renewable energy purchases	CO_2, CH_4 and N_2O emission factors by eGRID subregion	EPA, eGRID Emission Rate Summary Tables	Yes
Required scope 3	Business air travel	Custom air travel CO_2, CH_4 and N_2O emission factor model	GSA Travel MIS	N/A
	T&D losses	Loss factors	EPA eGRID and DOE 1605(b), Technical Guidelines	N/A
Optional scope 3	Ground business travel	Vehicle CO_2, CH_4 and N_2O emission factors	EPA Climate Leaders, Optional Emissions Guidance	Yes
	Commuter travel	Public Transit CO_2, CH_4, and N_2O emission factors		Yes

*Emission factors used for this methodology are the same as those for the default methodology, in addition to site-specific variables.

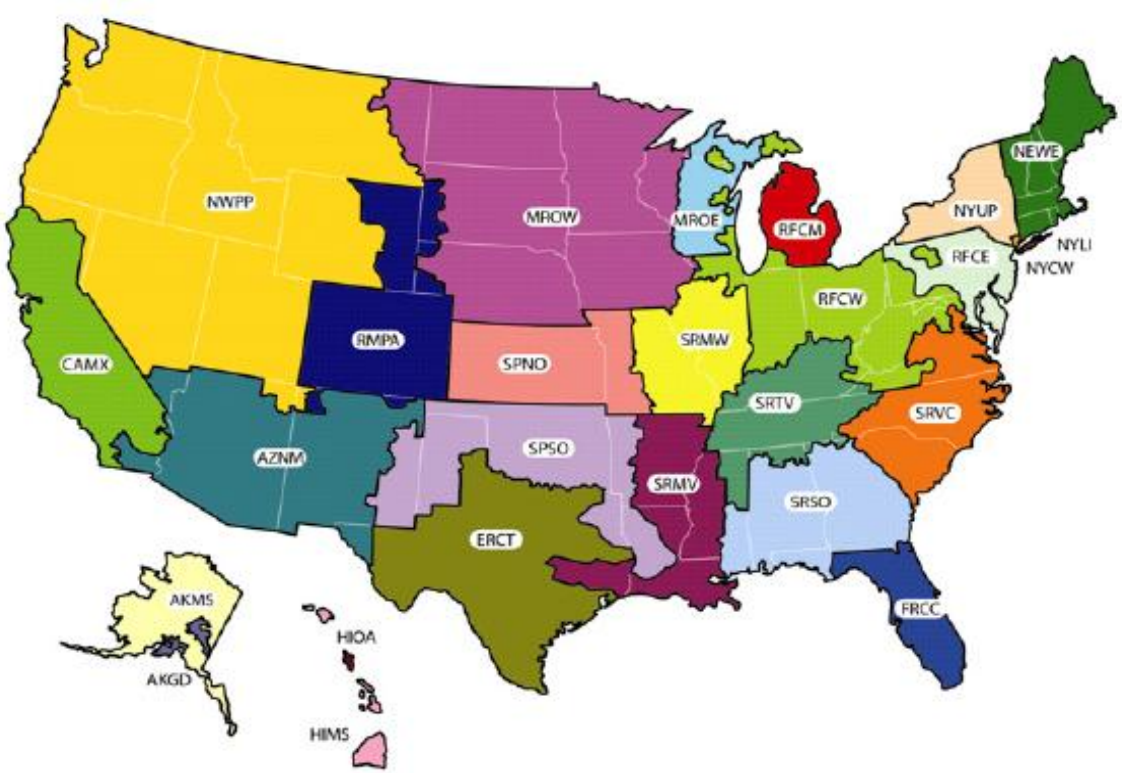
†Emission factors used for this methodology are not the same as those for the default methodology, but must be generated by the user or obtained from the utility provider.

Scope 2 Output Emission Rate Factors and Reporting by eGRID Subregion

For scope 2 electricity, the GHG Reporting Portal will use the eGRID subregion output emission rate factors provided by the EPA eGRID database to calculate default category GHG emissions. This database divides the electric grid into 26 subregions with unique emission factors based on the regional electricity generation mix. Figure 2-1 shows the eGRID subregion map illustrating the approximate boundaries of the eGRID subregions, which are not all defined by clear geographic boundaries but by utility areas. EPA's Power Profiler can be used to determine the appropriate eGRID subregion for a particular facility or building. See www.epa.gov/powerprofiler.

Agencies are responsible for reporting their electricity usage according to these subregions. Agencies can map a facility's ZIP code to the corresponding eGRID subregion using the EPA Power Profiler website.[13] If an agency cannot map FY 2008 electricity data by region, percentage factors determined from the FY 2010 electricity usage may be applied to the FY 2008 consumption to allocate this usage. Agencies reporting facilities in U.S. territories or choosing to report facilities in foreign nations must use emission factors from DOE 1605(b) Technical Guidelines.[14]

Figure 2-1: eGRID Subregions



[13] EPA Power Profiler. See www.epa.gov/powerprofiler.
[14] DOE 1605(b) Emission Factors. See www.eia.doe.gov/oiaf/1605/emission_factors.html.

Appendix A—Calculating Scope 1 Emissions

This appendix describes the scope 1 emission sources most commonly operated by Federal agencies, as well as required data, recommended data sources, and the default and advanced calculation methodologies.

This appendix provides calculation methodologies for the following:

- Stationary combustion: electricity, steam, heating
- Biomass combustion
- Mobile combustion: fossil fuels
- Mobile combustion: biofuel
- Fugitive F-gas emissions
- Wastewater treatment
- Landfills and solid waste facilities
- Industrial process emissions.

A.1 Stationary Combustion: Electricity, Heating, Steam

Description

Scope 1 stationary combustion emissions result from the generation of electricity, heat, or steam from sources owned and controlled by the agency. This includes emissions from use of boilers, furnaces, turbines, and emergency generators.

A.1.1 Default Methodology (Calculated by GHG Reporting Portal)

Data Sources

The default methodology is a fuel-use method, rather than direct emissions monitoring (i.e., continuous emissions monitoring) or direct sampling, as fuel use is already tracked and reported to FEMP annually.[15] If a source is not currently reported to FEMP but within an agency's operational control, these data may be available in bulk fuel or delivery receipts, contract or agency purchase records, stock inventory documentation, or maintenance records on turbines or emergency generators, furnaces, and boilers. (See Table A-1.)

Table A-1: Stationary Combustion Default Data Sources

Data Element	Preferred Source
Electricity Generation: Total amount of natural gas, coal, fuel oil, diesel, gasoline, propane, and other fuels consumed by generators	• FEMP Energy Report

[15] In the EPA MRR, this approach is considered a Tier 1 method.

and/or turbines	
Steam Production: Total amount of fuels consumed	• See above
Heat: Total amount of fuels consumed	• See above
Emission Factor	• See Table D-2

Calculation Steps[16]

The methodology used to calculate scope 1 emissions from stationary combustion is described below. Using the default methodology, agencies will enter the activity data from step 1 into the GHG Reporting Portal. The portal will conduct steps 2 through 5.

1. Determine the amount of fuel consumed annually
2. Determine the appropriate CO_2 emission factors for each fuel.
3. Determine the appropriate CH_4 and N_2O emission factors for each fuel
4. Calculate each fuel's GHG emissions and convert to MT
5. Convert CH_4 and N_2O emissions to MT CO_2e and determine the total emissions

Step 1: Determine the amount of fuel consumed annually

Identify all fuels combusted at the agency's facilities. Much of these data should already be collected and reported at the agency level in the FEMP Energy Report. When needed, the agency should convert the fuel-use data from physical units (mass or volume) to energy units (million BTU, or MMBtu) using the HHVs available in Table D-2.[17] These data are entered into the GHG Reporting Portal.

Fuel consumed [MMBtu] =
Fuel consumed [units of fuel type] ● HHV [MMBtu/units of fuel type]

Step 2: Determine the appropriate CO_2 emission factors for each fuel

The GHG Reporting Portal identifies the CO_2 emission factors by fuel type (see Table D-2).

Step 3: Determine the appropriate CH_4 and N_2O emission factors for each fuel

The GHG Reporting Portal identifies the CH_4 and N_2O emission factors by fuel type.[18]

Step 4: Calculate each fuel's GHG emissions and convert to MT

[16] Primary reference: EPA, Technical Support Document (TSD) for Stationary Fuel Combustion Emissions: Proposed Rule for Mandatory Reporting of Greenhouse Gases (MRR), 40 CFR 98, Subpart C, January 30, 2009.
[17] Also see TSD MRR Stationary Sources, 40 CFR 98, Subpart C, Tables C-1 and C-2 for emission factors.
[18] If the agency wishes to pursue a more advanced approach, it may substitute site-specific emission factors using data that consider the end-use sector (such as commercial or industrial) or other considerations, when applicable. Emission factors are also identified for specific types of combustion equipment for sites with significant stationary emissions. The Climate Registry, *Local Government Operations Protocol* (2008), Table G.4.

The GHG Reporting Portal multiplies the annual fuel consumed (Step 1) by the emission factors for CO_2 (Step 2), as well as the fuel consumed by emission factors for CH_4 and N_2O. It converts units into MT.

Equation A-1: Stationary Combustion GHG Emissions[19]

CO_2 Emissions [MT] = Fuel consumed [MMBtu] ● CO_2 emission factor [kg/MMBtu] ● 0.001 [MT/kg]
CH_4 Emissions [MT] = Fuel consumed [MMBtu] ● CH_4emission factor [kg/MMBtu] ● 0.001 [MT/kg]
N_2O Emissions [MT] = Fuel consumed [MMBtu] ● N_2O emission factor [kg/MMBtu] ● 0.001 [MT/kg]

Step 5: Convert CH_4 and N_2O emissions to MT CO_2e and determine the total emissions

The GHG Reporting Protocol uses the global warming potential (GWP) values (found in Table D-13) to convert CH_4 and N_2O emissions to units of CO_2e. It sums emissions from all three gases to determine total MT CO_2e.

Equation A-2: Stationary Combustion MT CO_2e Emissions

CO_2e Emissions (MT CO_2e) = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

Example A-1: Stationary Combustion

Step 1: Determine the amount of fuel consumed annually An agency consumes 1,000 CCF (hundred cubic feet) of natural gas.
Fuel consumed [MMBtu] = Fuel consumed [KCUFT] ● HHV [MMBtu/scf[20]] = (100 [KCUFT] ● 1000 [scf/KCUFT]) ● 1.028 x 10^{-3} [MMBtu/scf] = 102.8 [MMBtu]
Step 2: Determine the appropriate CO_2 emission factors for each fuel The CO_2 emission factor for natural gas is 53.02 kg CO_2/MMBtu. *Step 3: Determine the appropriate CH_4 and N_2O emission factors for each fuel* The natural gas emission factors for CH_4 and N_2O are 1.0 x 10^{-3} and 1.0 x 10^{-4} kg/MMBtu. *Step 4: Calculate each fuel's GHG emissions and convert to MT*
Equation A-1: Stationary Combustion GHG Emissions **CO_2 Emissions [MT] =** Fuel consumed [MMBtu] ● CO_2 emission factor [kg/MMBtu] ● 0.001 [MT/kg] = 102.8 [MMBtu] ● 53.02 [kg/MMBtu] ● 0.001 [MT/kg] = 5.450 [MT CO_2]
CH_4 Emissions [MT] = Fuel consumed [MMBtu] ● CH_4emission factor [kg/MMBtu] ● 0.001 [MT/kg]

[19] For clarity, the symbol "●" has been used to indicate multiplication instead of symbols such as "×."
[20] Standard cubic feet (SCF).

= 102.8 [MMBtu] ● 1.0 x 10^{-3} [kg/MMBtu] ● 0.001 [MT/kg]
= 1.028 x 10^{-4} [MT CH_4]

N_2O Emissions [MT] = Fuel consumed [MMBtu] ● N_2O emission factor [kg/MMBtu] ● 0.001 [MT/kg]
= 102.8 [MMBtu] ● 1.0 x 10^{-4} [kg/MMBtu] ● 0.001 [MT/kg]
= 1.028 x 10^{-5} [MT N_2O]

Step 5: Convert CH_4 and N_2O emissions to MT CO_2e and determine total emissions

Equation A-2: Stationary Combustion MT CO_2e Emissions
CO_2e Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)
= 5.450 + (1.028 x 10^{-4} ● 21) + (1.028 x10^{-5} ● 310)
= 5.450 + 2.159 x 10^{-3} + 3.187 x 10^{-3}
= 5.455 [MT CO_2e]

Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

No advanced methodologies for stationary combustion are available for reporting.

A.2 Biomass and Biofuel Combustion

Description

Biomass combustion emissions usually come from boilers, backup generators, wood stoves, and incinerators. Biomass can include wood (cords, chips, pellets, etc.). Biofuels can include landfill gas and biodiesel in generators.

A.2.1 Default Methodology (Calculated by GHG Reporting Portal)

These calculations mirror the stationary combustion method (see Appendix A.1 and are summarized here. Biomass CO_2 must be calculated separately as biogenic emissions and reported outside of the scopes. The GHG Reporting Portal accounts for CH_4 and N_2O emissions as scope 1. (See Table A-2.)

Table A-2: Biomass Combustion Default Data Sources

Data Element	Preferred Source
Biomass by type: Total amount [MMBtu]	• Agency records
Emission Factor	• See Table D-2 by fuel type.

Calculation Steps

The default methodology includes the following steps. The GHG Reporting Portal will use the data entered by the federal manager in step 1 to complete steps 2 through 5.

1. Determine the amount of fuel consumed annually

2. Determine the appropriate CO_2 emission factors for each fuel
3. Determine the appropriate CH_4 and N_2O emission factors for each fuel
4. Calculate each fuel's GHG emissions and convert them to MT
5. Convert CH_4 and N_2O emissions to MT CO_2e and determine the total emissions

Example A-2: Biomass Combustion

Step 1: Determine the amount of fuel consumed annually
A facility burned 134 tons of wood waste in a biomass boiler to reduce its natural gas use.

Fuel consumed [MMBtu] = Fuel consumed [short tons] ● HHV [MMBtu/ton]
= 134 [short tons] ● 15.38 [MMBtu/short ton]
= 2,060.92 [MMBtu]

Step 2: Determine the appropriate CO_2 emission factors for each fuel
The CO_2 emission factor for this example is 93.80 kg/MMBtu.

Step 3: Determine the appropriate CH_4 and N_2O emission factors for each fuel
The wood waste emission factors for CH_4 and N_2O are 0.032 and 0.0042 kg/MMBtu.

Step 4: Calculate each fuel's GHG emissions and convert them to MT

Equation A-1: Biomass Combustion GHG Emissions

CO_2 Emissions [MT] = Fuel consumed [MMBtu] ● CO_2 emission factor [kg/MMBtu] ● 0.001 [MT/kg]
= 2,060.92 [MMBtu] ● 93.80 [kg/MMBtu] ● 0.001 [MT/kg]
= 193.31 [MT CO_2]

CH_4 Emissions [MT] = Fuel consumed [MMBtu] ● CH_4 emission factor [kg/MMBtu] ● 0.001 [MT/kg]
= 2,060.92 [MMBtu] ● 3.2×10^{-2} [kg/MMBtu] ● 0.001 [MT/kg]
= 6.59×10^{-2} [MT CH_4]

N_2O Emissions [MT] = Fuel consumed [MMBtu] ● N_2O emission factor [kg/MMBtu] ● 0.001 [MT/kg]
= 2,060.92 [MMBtu] ● 4.2×10^{-3} [kg/MMBtu] ● 0.001 [MT/kg]
= 8.66×10^{-3} [MT N_2O]

Step 5: Convert CH_4 and N_2O emissions to MT CO_2e and determine the total emissions

Equation A-2: Biomass Combustion MT CO_2e Emissions

Reported as scope 1 emissions:

CO_2e Emissions [MT CO_2e] = (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)
= (0.0659 [MT CH_4] ● 21) + (0.0087 [MT N_2O] • 310)
= 1.385 [MT **CO_2e**] + 2.683 [MT **CO_2e**]
= 4.08 [MT CO_2e]

Reported as biogenic (not scope 1):

CO_2e Emissions [MT CO_2e] = MT CO_2
= 193.31 [MT CO_2]

Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

A.3 Mobile Combustion: Fossil Fuels

Description

Vehicle fleets are the primary source of mobile fossil fuel emissions, but they can also come from non-highway vehicles (such as agriculture equipment), research aircraft, and waterborne vessels. Fuel types include gasoline, diesel, aviation gas, Jet-A, CNG, LPG, liquefied natural gas (LNG), E-85, and other fuels derived from fossil fuel sources.

Most CO_2 emissions, which account for the majority of emissions from mobile sources, can be calculated using fuel consumption data already reported to the FAST system for both the default and advanced methodology. CH_4 and N_2O emissions calculations vary depending on emission control technologies and distance traveled. FAST system fuel consumption data are used for the default methodology, but this methodology is limited to using a default value. Agencies may utilize specific fleet composition and fuel consumption to report using the advanced methodology.

A.3.1 Default Methodology (Calculated by GHG Reporting Portal)

Data Sources

The default methodology uses the data already reported in FAST and potentially other analogous agency-specific systems. The GHG Reporting Portal uses default factors to automatically calculate the CH_4 and N_2O emissions. (See Table A-3.)

Table A-3: Mobile Combustion: Fossil Fuels Default Data Sources

Data Element	Preferred Source
Annual Fuel Consumption: by type [Gal]*	• FAST system • Other analogous agency-specific systems
Emission Factor	• CO_2: see Table D-2 by fuel type. • CH_4 and N_2O: see Table D-4 by fuel type.

*This methodology applies to highway vehicles and alternative fuel vehicles, but not to non-highway vehicles such as ships and aircraft. For those vehicles, estimation of CH_4 and N_2O emissions is also based on fuel consumption.

Calculation Steps[21]

To calculate scope 1 emissions from mobile combustion of fossil fuels, agencies' vehicle fuel consumption data available in the FAST system will be imported automatically into the GHG Reporting Portal (Step 1). Similar import arrangements may be possible with other analogous agency-specific systems, as necessary. The portal will automatically perform steps 2 through 7:

1. Determine the total amount of fuel consumed by type

[21] EPA, Climate Leaders Technical Guidance, *Direct Emissions from Mobile Combustion Sources*, May 2008.

2. Determine the appropriate CO_2 emission factors for each fuel
3. Determine the appropriate CH_4 and N_2O emission factors for each fuel using default assumptions
4. Convert the CH_4 and N_2O emission factors from g/mile to kg/gal of fuel using default assumptions
5. Calculate the total CO_2 emissions and convert them to MT
6. Calculate the total CH_4 and N_2O emissions and convert them to MT
7. Convert CH_4 and N_2O emissions to MT CO_2e and determine the total emissions

Step 1: Determine the total amount of fuel consumed by type

The FAST system includes agency-level information on fuel consumption per fuel type. These data will be automatically imported from the FAST system into the GHG Reporting Portal and should be reviewed. The agency can modify the imported data to correct inaccuracies or to include mobile emissions sources not currently included in FAST system but under the operational control of the agency. The GHG Reporting Portal automatically converts GGEs to gallons using the conversions in Table D-15.

Step 2: Determine the appropriate CO_2 emission factors for each fuel

The GHG Reporting Portal will select the appropriate emission factor for each fuel. Table D-2 shows CO_2 emission factors by fuel based on national fuel averages. It will multiply the default HHV [MMBtu/gal] by the default emission factor [kg/MMBtu] to determine the kg/gal CO_2 emission factor automatically.

Step 3: Determine the appropriate CH_4 and N_2O emission factors for each fuel using default assumptions

CH_4 and N_2O emission factors are developed in grams per mile. Because the FAST system does not correlate fuel use by type of vehicle or mileage, this methodology requires significant assumptions about the mobile inventory. It conservatively estimates the amount of CH_4 and N_2O emissions from mobile sources by using a high emission factor under available control technology from 2005 for the entire fleet.[22] The current default calculation estimates mobile CH_4 and N_2O emissions on the basis of emission factors for a fleet of 2005 light-trucks using low emission vehicle (LEV) technology or advanced controls (see below). This default will be updated as necessary in future revisions to the Guidance. Agencies with more detail on the vehicle fleet composition connected to fuel use can choose to use the advanced calculation methodology described after this section, either with full data or weighted averages per vehicle and fuel type.

[22] The GHG Reporting Tool uses values from 5 years prior to the reporting year, as GSA leases vary from 3 to 8 years, depending on type and fuel. In 2005, the majority of all vehicles were Tier 2 control technologies, so this approach uses the second largest (and more conservative) group—low emissions vehicles and advanced control mechanisms. The average model year CH_4 and N_2O emissions did not vary significantly between 2001 and 2005. Future revisions will revisit and update these assumptions as new emission factor data become available.

For FY 2010 reporting, the GHG Reporting Portal will use the emission factors for a 2005 gasoline light-duty truck with LEV technology or advanced controls (0.0157 g N_2O/mile and 0.0148 g CH_4/mile). (See Table D-4.[23])

Step 4: Convert the CH_4 and N_2O emission factors from g/mile to kg/gal of fuel using default assumptions

For FY 2010 reporting, the GHG Reporting Portal will use the example 2005 light-duty truck with a fuel efficiency of 16.2 miles per gallon (MPG) for the fleet.[24] The GHG Reporting Portal then will multiply the default MPG (16.2 MPG for FY 2010) by the CH_4 and N_2O emission factors in g/mile (Step 3) to determine a kg/gal emission factor.

Converted mobile emission factor [kg/gal] =
CH_4 or N_2O emission factor [g/mi] ● Default vehicle efficiency [mi/gal] ● 0.001 [kg/g]

Step 5: Calculate the total CO_2 emissions and convert them to MT

To determine CO_2 emissions from mobile combustion, the GHG Reporting Portal will multiply fuel use (Step 1) by the CO_2 emission factor (Step 2), and then convert kg to MT.

Equation A-3: Mobile Combustion of CO_2 (Fossil Fuels)

CO_2 emissions [MT CO_2] =
Vehicle fuel consumption [gal] ● CO_2 emission factor [kg/gal] ● 0.001 [MT/kg]

Step 6: Calculate the total CH_4 and N_2O emissions and convert them to MT

The GHG Reporting Portal will multiply the fuel use (Step 1) by the converted mobile emission factors for CH_4 and N_2O (Step 4) and then convert kg to MT.

Equation A-4: Mobile Combustion of CH_4 and N_2O (Fossil Fuels)

CH_4 emissions [MT CH_4] =
Vehicle fuel consumption [gal] ● CH_4 emission factor [kg/gal] ● 0.001 [MT/kg]
N_2O emissions [MT N_2O] =
Vehicle fuel consumption [gal] ● N_2O emission factor [kg/gal] ● 0.001 [MT/kg]

Step 7: Convert CH_4 and N_2O emissions to MT CO_2e and determine the total emissions

[23] EPA, Climate Leaders, *Mobile Combustion Sources*, May 2008, Tables A-1, A-6, and A-7.
[24] US DOT, FHWA, Highway Statistics 2005, Table VM-1. See www.fhwa.dot.gov/policy/ohim/hs05/pdf/vm1.pdf.

The GHG Reporting Protocol uses the GWP values (found in Table D-13) to convert CH_4 and N_2O emissions to units of CO_2e. It sums emissions from all three gases to determine total MT CO_2e.

Equation A-5: Mobile Combustion MT CO_2e Emissions

CO_2e Emissions (MT CO_2e) =
MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

Example A-3: Mobile Combustion (Fossil Fuels)—Default Methodology

Step 1: Determine the total amount of fuel consumed by type
The agency fleet consumed 500,000 gallons of gasoline.

Step 2: Determine the appropriate CO_2 emission factors for each fuel

CO_2 emission factor [kg/gal] = Gasoline HHV [MMBtu/gal] ● Gasoline emission factor [kg/MMBtu]
= 0.125 [MMBtu/gal] ● [70.22 kg/MMBtu]
= 8.78 [kg/gal]

Step 3: Determine the appropriate CH_4 and N_2O emission factors for each fuel using default assumptions
The default emission factors for the default vehicle (light truck, LEV technology, 2005) are 0.0157 g/mi for N_2O and 0.0148 g/mi for CH_4.

Step 4: Convert the CH_4 and N_2O emission factors from g/mile to kg/gal of fuel using default assumptions

CH_4 emission factor [kg/gal] = CH_4 emission factor [g/mi] ● Default vehicle efficiency [mi/gal] ● 0.001 [kg/g]
= 0.0148 [g/mi] ● 16.2 [mi/gal] ● 0.001 [kg/g]
= 2.40×10^{-4} [kg/gal]

N_2O emission factor [kg/gal] = N_2O emission factor [g/mi] ● Default vehicle efficiency [mi/gal] ● 0.001 [kg/g]
= 0.0157 [g/mi] ● 16.2 [mi/gal] ● 0.001 [kg/g]
= 2.54×10^{-4} [kg/gal]

Step 5: Calculate total CO_2 emissions and convert them to MT

Equation A-3: Mobile Combustion of CO_2 (Fossil Fuels)
CO_2 emissions [MT CO_2] = Vehicle fuel consumption [gal] ● CO_2 emission factor [kg/gal] ● 0.001 [MT/kg]
= 500,000 [gal] ● 8.78 [kg/gal] ● 0.001 [MT/kg]
= 4,390 [MT CO_2]

Step 6: Calculate total CH_4 and N_2O emissions and convert them to MT

Equation A-4: Mobile Combustion of CH_4 and N_2O (Fossil Fuels)
CH_4 emissions [MT CH_4] = Vehicle fuel consumption [gal] ● CH_4 emission factor [kg/gal] ● 0.001 [MT/kg]
= 500,000 [gal] ● 2.40×10^{-4} [kg/gal] ● 0.001 [MT/kg]
= 1.20×10^{-1} [MT CH_4]

N_2O emissions [MT N_2O] = Vehicle fuel consumption [gal] ● N_2O emission factor [kg/gal] ● 0.001 [MT/kg] = 500,000 [gal] ● 2.54 x 10^{-4} [kg/gal] ● 0.001 [MT/kg] = 1.27 x 10^{-1} [MT N_2O]
Step 7: Convert CH_4 and N_2O emissions to MT CO_2e and determine total emissions
Equation A-5: Mobile Combustion MT CO_2e Emissions **CO_2e Emissions (MT CO_2e)** = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP) = 4,390 [MT CO_2] + (1.20 x 10^{-1} [MT CH_4] ● 21) + (1.27 x 10^{-1} [MT N_2O] ● 21) = 4,390 [MT CO_2] + 2.52 [MT CO_2e] + 39.37 [MT CO_2e] **= 4,431.89 MT CO_2e**
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

A.3.2 Advanced Methodology (User Calculated)

Data Sources

The advanced calculation methodology uses data on annual mileage and fleet composition to find fleet-specific emissions totals for CH_4 and N_2O.

Table A-4: Mobile Combustion: Fossil Fuels Data Sources

Data Element	Preferred Source	Alternate Source
Annual fuel consumption data by type	• FAST system • Other agency resources, such as the operating and support management information system, when applicable • Agency non-fleet VE records	• Dollars spent on fuel and average price per unit of volume • Annual mileage and vehicle fuel economy reported • Hours operated (off-road vehicles)
Annual mileage by vehicle type, emission control technology, and fuel type* (for CH_4 and N_2O calculation only) [mi]	• Agency data on miles traveled	• Miles traveled estimates based on hours traveled and fuel economy • Weighted average percentages of vehicle type and efficiency data from vehicle population • Hours operated (off-road vehicles)
Emission factor	• CO_2: see Table D-2 by fuel type • CH_4 and N_2O: see Tables D-4 through D-6 by fuel type, vehicle type, and combustion technology	

*This applies to highway vehicles and alternative fuel vehicles, but not to non-highway vehicles such as ships and aircraft. For those vehicles, CH4 and N2O emissions are estimated from fuel consumption rather than distance traveled.

Calculation Steps for CO_2 Emissions

See Appendix A.2.1, Steps 1, 2, and 5 of the Default Methodology, for CO_2 emissions. To convert from GGEs, use the conversions in Table D-15.

Total fuel consumption [gal] = Total fuel [GGE] ÷ GGE factor [GGE/gal]

Calculation Steps for CH_4 and N_2O Emissions

Although not required, agencies with more alternative activity data (i.e., fleet fuel consumption by vehicle class) can choose to utilize this advanced methodology to more accurately estimate their fleet emissions. This increased accuracy can be used to better estimate (and get credit for) reductions obtained through certain fleet management strategies (such as creating a "cleaner" mix of fleet vehicles). Alternatively, if data on specific control technologies are not available, or are too labor intensive to generate, agencies can estimate CH_4 and N_2O emissions using a weighted average of available control technologies by model year and apply the sums to the advanced calculation methodology (see Table D-4 for average emission factors).

To calculate scope 1 CH_4 and N_2O emissions from the mobile combustion of fossil fuels, do the following:

1. Identify the vehicle type, fuel type, and technology type of all the vehicles
2. Determine the mileage by vehicle type
3. Determine the appropriate emission factors for fuel and vehicle type
4. Calculate CH_4 and N_2O emissions by vehicle type and convert them to MT
5. Determine the total annual MT CO_2e

Step 1: Identify the vehicle type, fuel type, and technology type of all the vehicles

The federal manager identifies all vehicles under operational control of the agency by vehicle type (passenger car, light-duty truck, heavy-duty truck, and/or motorcycle), fuel type (gasoline or diesel), and emission control technology (LEVs, moderate control technologies, etc.). See Table D-4 for control technologies and emission factors. See the EPA Climate Leader's Mobile Combustion Guidance for more detail on the tiered emission control technology.[25]

Step 2: Determine the mileage by vehicle type

For each vehicle type referenced in Table D-4, the federal manager determines distance traveled for the reporting period.

Step 3: Determine the appropriate emission factors for fuel and vehicle type

The federal manager selects the appropriate factors. (See Table D-4 and

[25] EPA, Climate Leaders, *Direct Emissions from Mobile Combustion Sources*, Appendix A, May 2008. See www.epa.gov/climateleaders/documents/resources/mobilesource_guidance.pdf.

Table D-5, for emission factors by vehicle type and technology.) See the EPA's Mobile Combustion guidance for weighted assumptions by year. The weighted assumptions provide the estimated emission factor by type of vehicle and year. Additional tables in Appendix A of EPA Climate Leaders Mobile Combustion guidance present the percentage of vehicles by type in each year that was designed with the EPA's tiered designations, which can be used if the vehicle population by type of technology is not known but date of purchase is. Agencies should establish the information available on their fleet and use the best estimates of its composition.

Step 4: Calculate the CH_4 and N_2O emissions by vehicle type and convert them to MT

For each category of vehicle type, technology, and fuel, the federal manager uses Equation A-6 for CH_4 and N_2O emissions.

Equation A-6: Total Mobile Combustion of CH_4 and N_2O (Fossil Fuels)

CH_4 Emissions [MT CH_4] =
Total miles traveled [mi] ● CH_4 emission factor [g/mi] ● 0.001 [kg/g] ● 0.001 [MT/kg]
N_2O Emissions [MT N_2O] =
Total miles traveled [mi] ● N_2O emission factor [g/mi] ● 0.001 [kg/g] ● 0.001 [MT/kg]

Step 5: Determine the total annual MT CO_2e

To determine the total CO_2e emissions, the manager multiplies by the appropriate GWP value for each gas found in Table D-13, and sums.

Equation A-7: Mobile Combustion MT CO_2e Emissions

CO_2e Emissions (MT CO_2e) =
MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

Example A-4: Mobile Combustion (Fossil Fuels)—Advanced Methodology

CO_2 Calculation
Step 1: Determine total amount of fuel consumed by type
A truck owned by the agency consumed 2,350 gallons of diesel fuel (Distillate Oil No. 2).

Step 2: Determine appropriate emission factors for each fuel

CO_2 emission factor [kg/gal] = HHV [MMBtu/gal] ● Diesel emission factor [kg/MMBtu]
= 0.138 [MMBtu/gal] ● 73.96 [kg/MMBtu]
= 10.21 [kg/gal]

Step 3:Calculate total CO_2 emissions and convert them to MT

Equation A-3: Combustion of CO2 (Fossil Fuels)
CO_2 emissions [MT] = Vehicle fuel consumption [gal] ● CO_2 emission factor [kg/gal] ● 0.001[MT/kg]
= 2,350 [gal] ● 10.21 [kg/gal] ● 0.001 [MT/kg]
= 23.99 [MT CO_2]

CH_4 and N_2O Calculation
Step 1: Identify the vehicle type, fuel type, and technology type of all the vehicles

The 1993 truck's average mileage is 15 mpg. It uses moderate emissions control technology.

Step 2: Determine mileage by vehicle type
The truck used 2,340 gallons of diesel fuel and averaged 15 mpg, driving a total of 35,250 miles.

Step 3: Determine the appropriate emission factors for fuel and vehicle type
The CH_4 and N_2O emission factors for a diesel light truck with moderate emission control technology are 0.0014 g/mile and 0.0009 g/mile, respectively.

Step 4: Calculate CH_4 and N_2O emissions by vehicle type and convert them to MT

Equation A-6: CH_4 and N_2O emissions
CH_4 Emissions [MT] = Total miles traveled [mi] ● CH_4 emission factor [kg/mi] ● 0.001 [MT/kg]
= 35,250 miles ● 0.0014 [g/mi] ● 0.001 [kg/g] ● 0.001 [MT/kg]
= 4.94×10^{-5} [MT CH_4]

N_2O Emissions [MT] = Total miles traveled [mi] ● N_2O emission factor [kg/mi] ● .001 [MT/kg]
= 35,250 miles ● 0.0009 [g/mi] ● 0.001 [kg/g] ● 0.001 [MT/kg]
= 3.17×10^{-5} [MT N_2O]

Step 5: Determine the total annual MT CO_2e

Equation A-7: Mobile Combustion MT CO_2e Emissions—Advanced
CO_2e Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)
= 23.99 [MT CO_2] + (4.94×10^{-5} [MT CH_4] ● 21) + (3.17×10^{-5} [MT N_2O] ● 310)
= 23.99 [MT CO_2] + 1.04×10^{-3} [MT CO_2e] + 9.83×10^{-3} [MT CO_2e]
= **24.00 [MT CO_2e]**

Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

Non-Highway Vehicles

A list of default emission factors for non-highway vehicles are included in Table D-6 to assist in calculating emissions for aircraft, boats and ships, agriculture equipment, and various other vehicle and fuel types. Estimating emissions from these non-highway vehicles also requires data on the quantity of fuel consumed by fuel types. The same general calculation methodology described for highway vehicles applies to non-highway vehicles. For non-highway vehicles recorded by hours traveled, agencies should use known vehicle efficiency data and report the resulting total fuel usage or mileage. Additional emission factors for non-highway vehicles are available in EPA's Climate Leader's guidance, Table A-6: www.epa.gov/stateply/documents/resources/mobilesource_guidance.pdf.

A.4 Mobile Combustion: Biofuels

Description

Biofuels combusted in vehicles, such as cars, trucks, airplanes, and water vessels, produce CO_2, CH_4, and N_2O emissions. Agencies should include CH_4 and N_2O emissions as scope 1, and CO_2 emissions should be reported outside of the scopes as biogenic emissions. The CH_4

and N_2O calculations are the same as those outlined in Appendix A.3. Because the reporting requires separately addressing the biogenic and non-biogenic fractions of fuels separately, the calculation steps for the methodologies below distinguish between CO_2 emissions calculations and those from CH_4 and N_2O. The GHG Reporting Portal automatically separates these emissions in the default methodology.

A.4.1 Default Methodology (Calculated by GHG Reporting Portal)

Data Sources

Use the FAST system and FEMP energy reporting data for fuel consumption totals from biofuel combusted by mobile sources (Table A-5).

Table A-5: Mobile Combustion: Biofuel Default Data Sources

Data Element	Preferred Source
Annual fuel consumption data by type	• FAST system and other FEMP data reporting sources
CH_4 and N_2O: annual fuel consumption data by type	• FAST system and other FEMP data reporting sources
Biobased fraction of fuel	• Calculated percentage of annual fuel consumption
Emission factor	• CO_2: see Table D-2 by fuel type • CH_4 and N_2O: see Tables D-4 through D-6 by fuel type

Calculation Steps for CO_2 Emissions[26]

To calculate scope 1 CO_2 emissions from mobile combustion of biofuels, agencies' vehicle fuel consumption data available in the FAST system will be imported automatically into the GHG Reporting Portal (Step 1).[27] The agency also enters the appropriate non-fleet VE data as part of the FEMP energy reporting requirements. The GHG Reporting Portal will automatically perform steps 2 through 4:

1. Determine the total amount of fuel consumed by type
2. Determine the biofuel and fossil fuel portions of each fuel type (blend)
3. Select the appropriate CO_2 emission factor for fuel type
4. Calculate the CO_2 emissions by biofuel and fossil fuel type

Step 1: Determine the total amount of fuel consumed by type

The agency POC reviews data available from the FAST system on B20 and B100. The federal manager enters data for FEMP energy reporting, including mobile combustion of biofuel and

[26] Primary Reference: EPA, Climate Leaders Technical Guidance, *Direct Emissions from Mobile Combustion Sources*, May 2008.
[27] Additional agency-specific analogous data systems may potentially be linked to the GHG Reporting Portal.

identifying the biofuel blend. Biofuel blends are indicated in terms of the fraction of biofuel blended with a fossil fuel. For example, B20 contains 20 percent biodiesel and 80 percent petroleum diesel. Likewise with ethanol blends, E85 contains 85 percent ethanol and 15 percent gasoline. Under current FAST reporting rules, however, E10 is considered a standard gasoline formulation and B5/B10 is only considered as standard petrodiesel with a fuel additive (biodiesel). B20 and larger are considered and calculated as biodiesel per current Federal fleet guidance. When using FAST system data, the agency may have to convert them from GGEs (see Table D-15 for conversion factors).

Step 2: Determine the biofuel and fossil fuel portions of each fuel type (blend)

The fractional components of the biofuels have different carbon contents, requiring the CO_2 emissions for each fraction to be calculated separately. The GHG Reporting Portal will calculate the total amount of each fraction of fuel.

Step 3: Select the appropriate CO_2 emission factor for fuel type

The GHG Reporting Portal identifies the appropriate emission factor for each type and fraction of fuel (see Table D-2 for fuel emission factors).

Step 4: Calculate the CO_2 emissions by biofuel and fossil fuel type

For each category of biofuel and fossil fuel type, the federal manager uses Equation A-8 to calculate their respective CO_2 emissions.

Equation A-8: Biofuel CO_2 Emissions

Biofuel CO_2 emissions [MT] =
Total fraction of biofuel in fuel consumed [gal] ● CO_2 emission factor [kg/gal] ● 0.001 [MT/kg]

Fossil fuel CO_2 emissions [MT] =
Total fraction of fossil fuel in fuel consumed [gal] ● CO_2 emission factor [kg/gal] ● 0.001 [MT/kg]

The GHG Reporting Portal reports CO_2 generated from the fossil fuel fraction as scope 1; the quantity of CO_2 from the biofuel portion is calculated separately as biogenic.

Calculation Steps for CH_4 and N_2O Emissions

Use the method described in Appendix A.3 to calculate the CH_4 and N_2O emissions in MT CO_2e. Report CH_4 and N_2O emissions for both fossil and biofuel components under scope 1. There are no biogenic CH_4 and N_2O emissions from either fossil or biofuel mobile combustion.

A.4.2 Advanced Methodology (User Calculated)

Data Sources

Data sources for calculating CO_2 emissions are the same as in the default method, and sources for calculating CH_4 and N_2O are the same as in Appendix A.3.

Calculation Steps for CO_2, CH_4, and N_2O Emissions

The advanced methodology for CO_2 is the same as the default. The CH_4 and N_2O advanced methodology is described in Appendix A.3.2. Report CH_4 and N_2O emissions for both fossil and biofuel components under scope 1. There are no biogenic CH_4 and N_2O emissions from either fossil or biofuel mobile combustion.

Example A-5: Biofuel Combustion—Advanced

Step 1: Determine the total amount of fuel consumed by type
A light truck owned by an agency consumed 2,500 gallons of B20.

Step 2: Determine the biofuel and fossil fuel portions of the blend
This equates to 500 gallons of biodiesel and 2,000 gallons of regular petrodiesel.

Step 3: Select the appropriate CO_2 emission factors for fuel type
The biodiesel emission factor is 9.45 kg CO_2/gal and the petrodiesel (Distillate Oil No. 2) emission factor is 10.21 kg CO_2/gal.

Step 4: Determine the biofuel and fossil fuel portions of each fuel type and calculate the CO_2 emissions

Equation A-8: Biofuel CO_2 Emissions
Report as biogenic (not scope 1):
Biodiesel CO_2 emissions [MT] = Total fraction of biodiesel in fuel consumed [gal] ● CO_2 emission factor [kg/gal] ● 0.001 [MT/kg]
= 500 [gal] ● 9.45 [kg/gal] ● 0.001 [MT/kg]
= 4.73 [MT CO_2]

Report as scope 1:
Petrodiesel CO_2 emissions [MT] = Total fraction of petrodiesel in fuel consumed [gal] ● CO_2 emission factor [kg/gal] ● 0.001 [MT/kg]
= 2,000 [gal] ● 10.21 [kg/gal] ● 0.001 [MT/kg]
= 20.42 [MT CO_2]

The scope 1 CO_2 emissions are added to the total amount of CH_4 and N_2O emissions calculated below and reported as scope 1 mobile biomass emissions. The biogenic CO_2 emissions above are reported separately (see Example A-3 for more explanation). The truck has an average efficiency of 21 MPG and used 2,500 gallons; it traveled approximately 52,500 miles.

Report as scope 1—CH_4 and N_2O Emissions Calculations:
Equation A-6: CH_4 and N_2O emissions
CH_4 Emissions [MT] = Total miles traveled [mi] ● CH_4 emission factor [kg/mi] ● 0.001 [MT/kg]
= 52,500 miles ● 0.0014 [kg/mi] ● 0.001 [MT/kg]
= 7.35×10^{-2} [MT CH_4]

N_2O Emissions [MT] = Total miles traveled [mi] ● N_2O emission factor [kg/mi] ● 0.001 [MT/kg]
= 52,500 miles ● 0.0009 [kg/mi] ● 0.001 [MT/kg]
= 4.73×10^{-2} [MT N_2O]

Equation A-7: Mobile Combustion MT CO_2e Emissions—Advanced
CO_2e Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)
= 20.42 [MT CO_2] + (7.35 x 10^{-2} [MT CH_4] ● 21) + (4.73 x 10^{-2} [MT N_2O] ● 310)
= 20.42 [MT CO_2] + 1.54 [MT CO_2e] + 14.66 [MT CO_2e]
= **36.63 [MT CO_2e]**

Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

A.5 Fugitive Emissions: Refrigerants and Fluorinated Gases

Description

This section discusses default and advanced approaches for calculating scope 1 fugitive GHG emissions from refrigerants and F-gases. For purposes of inventory development, fugitive emissions are GHG emissions resulting from equipment operations or practices that do not pass through a stack, chimney, or other functionally equivalent opening (point source) and which are not captured or destroyed by an emissions control system. Agencies should note that ozone depleting substances (CFCs and HCFCs) are not considered GHGs in the context of EO 13514 and other GHG accounting systems. Thus, it is recommended that agencies carefully track both refrigerant type and quantity to avoid reporting challenges with these commingled refrigerant gases.[28]

F-gas fugitive emissions can occur during the manufacture, installation, use, service, and disposal of heating, ventilation, and air conditioning (HVAC) and refrigeration equipment; mobile source air-conditioning equipment; and electrical equipment in which SF_6 or PFCs are used as electrical insulators. Such electrical equipment includes gas-insulated circuit breakers, switch gears, substations, gas-insulated lines, and some transformers.

For purposes of the TSD, it is assumed that all agency emissions of F-gases are "fugitive." If an agency has F-gas emissions that are "non-fugitive" (pass through a stack or chimney, or are intentionally released during research), an agency must calculate these emissions and include them in their inventory as scope 1.[29]

General Data Sources

In general, the information required to estimate F-gas emissions from HVAC, refrigeration, and electrical equipment consists of data on F-gas consumption and the net growth (or decline) of the total charge (nameplate capacity) of the equipment during the year. The net growth or

[28] CO_2, CH_4, and N_2O are not F-gases though there are also fugitive emissions of these GHGs. Fugitive emission of these GHG could stem from there use as specialty gases, waste water treatment, and solid waste facilities. See Appendices A-6 and A-7 on wastewater treatment and solid waste facilities, respectively).
[29] CEQ acknowledges that agencies may not be able to collect fugitive emission data for the FY 2008 baseline. Agencies are required to do so to the best of their ability.

decline of the total charge is tracked by the total quantities of equipment newly installed or retired. The total charge is also useful for its own sake in applying the screening analysis (discussed further below) or calculating emission rates (such as kg HFC emitted per kg HFC charge).

The ease and ability of obtaining the underlying activity data needed to calculate fugitive GHG emissions may be influenced by the size, mission, and maintenance capabilities of an agency. Larger organizations may operate agency-specific logistics and supply management systems at the facility level that track the requisition, purchase, receipt, storage, issue, shipment, disposition, and identification of equipment and supply materials and may maintain equipment in-house. If these systems are not centrally accessible at the agency headquarters level, formal data calls may be needed to obtain the necessary data from individual agency locations.

Smaller organizations may not have the same logistics, data management, and equipment maintenance needs and/or may contract out such services. If F-gas purchase data are not available from local sources, best judgment estimates may be needed. Agencies may consider modifying facility support or service contracts to require contractors to provide these data for future inventories.

Specific data requirements will depend on the methodology applied, as described below.

Default and Advanced Methodologies[30]

Depending on the quality of available underlying data, any of the following four methodologies may be used for calculating fugitive F-gas emissions:

1. Federal supply system transaction screening approach (default)
2. Material balance approach (advanced)
3. Simplified material balance approach (advanced)
4. Screening approach (advanced)

The default method is a simplified screening method based on the use of Federal supply system requisition and/or local purchase data. The material balance approach is generally the most accurate method of determining fugitive emissions. The simplified material balance approach is potentially more accurate than the screening approaches, and it can be used by agencies without detailed inventory information on each F-gas.

The screening approach can be used to calculate emissions or determine whether material balance methods are appropriate. This requires multiplying the quantity of F-gases by default emission factors for the specific type of equipment or emission event.

[30] Primary Reference: EPA, Climate Leaders Technical Guidance, *Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Equipment*, May 2008; EPA TSD for Emissions from Production of Fluorinated GHGs: Proposed Rule for Mandatory Reporting of Greenhouse Gases, February 2009.

A.5.1 Default Methodology (Calculated by GHG Reporting Portal)

The Federal supply system transaction screening approach (default) is a much simplified version of the material balance approach used by several Federal agencies in conjunction with the development of inventories of ODSs. Central to this methodology is the assumption that subtracting the quantity of F-gas returned from the quantity an agency purchases or issues to maintain equipment can be used as a reasonable surrogate for actual emissions. This assumption is reasonable when the total charge of a particular F-gas in the installed equipment is fairly constant from year to year. However, if the total charge is declining because more equipment containing the F-gas is being retired than installed, this assumption could lead to an underestimate of F-gas emissions.[31] If the agency knows that its total charge is declining significantly, it can consider using one of the other methodologies.

Furthermore, agencies with cyclical operations or events that use this default screening approach may find that a single reporting year is not representative of their scope 1 F-gas fugitive emissions (HFCs, PFCs, and SF_6). As discussed in Chapter 5.3 of the Guidance, agencies may choose to calculate a 3-year rolling average base year value for their specific scope 1 fluorinated fugitive emissions. The FY 2008 base year must consist of the average scope 1 fluorinated gas fugitive emissions for FY 2006, FY 2007, and FY 2008. If an agency uses a 3-year rolling average base year for fugitive emission, it must continue to use it for subsequent reporting years. Agencies must note the use of this rolling average approach in the "Other Information" section of their qualitative statement. Agencies may not use the rolling average approach for their fugitive emissions, only for the F-gas fugitive emissions category.

Data Sources

Agencies will need to obtain purchase and supply requisition data on each F-gas from local or centralized sources (see Table A-6). Chemical compounds are often listed by chemical name or trade name, which can lead to confusion when a single compound is referred to by multiple names. The Chemical Abstract Service (CAS) number is a unique numeric identifier for chemical compounds that should be used when searching a chemical inventory database to avoid such confusion.

Table A-6: Fugitive F-Gas Default Data Sources—The Federal Supply System Transaction Screening Approach

Data Element	Preferred Source	Alternate Source
Amount and type of each F-gas issued from procurement and storage [lb]	• GSA • Defense Logistics Agency	• Local hazardous material management/distribution centers

[31] Agencies should ensure there is no double counting or underreporting as they switch equipment (from R-22 to HFC-based refrigerants). If little or no new equipment is being installed, but significant amounts of old equipment are being retired, emissions can occur without resulting in demand for new gas. Specifically, emissions can occur between the final servicing of equipment and its retirement or during its retirement. These emissions could account for most or even all of the equipment charge. When at least some of the equipment charge is recovered and recycled, that charge can be used to service existing equipment (whose charge has leaked previously), offsetting demand for new gas that would have occurred if the gas from the retiring equipment were not available.

	• Agency logistics/supply organizations • Chemical inventory tracking system	• Purchase records • Maintenance records
Amount recovered from equipment and the amount returned to the supply system [lb]	• See above	• See above

Calculation Steps

To calculate scope 1 emissions from fugitive F-gas emissions, do the following:

1. Collect transaction data
2. Find the difference in the amounts recovered and returned to estimate annual emissions
3. Convert them to MT CO_2e and total emissions

Step 1: Collect transaction data

The federal manager identifies the CAS numbers of the F-gases used and obtains supply system transactional data to determine the amount and type of each F-gas issued from storage. If F-gas purchase data are not available from local sources, the federal manager may need to make best judgment estimates. These data are entered into the GHG Reporting Portal, which converts lb to kg (see Table D-14 for conversion factors).

Step 2: Find the difference in amount recovered and returned to estimate annual emissions

The GHG Reporting Portal subtracts from amount issued the amount recovered from equipment and the amount returned to the supply system. In some cases, the federal manager may need to first convert gas reported in units of volume to units of mass before estimating emissions. (See the examples following this section.)

Equation A-9: Annual F-Gas Emissions

Annual Emissions [MT F-gas] =
$(I - R) \bullet 4.536 \times 10^{-4}$ [MT/lb]

Where:

I = Amount of F-gas issued from supply system [lb]

R = Amount of F-gas returned to supply system from equipment, which includes the amount recovered from equipment during maintenance and the unused amount originally issued from supply [lb]

Step 3: Convert to MT CO_2e and total emissions

The GHG Reporting Portal will multiply the F-gas annual emissions [MT F-gas] by the GWP of each F-gas to calculate the CO_2e emissions (see Equation A-10). It will sum all F-gas emissions. (See Table D-13 for GWP values.)

Equation A-10: Conversion of F-Gas to CO_2e

CO_2e [MT F-gas] =
Annual Emissions [MT] ● F-gas GWP

In Examples A-6 and A-7, the refrigerant HFC-23 (CAS number 75-46-7) is listed under two names: trifluoromethane and fluoroform, illustrating the importance of using CAS numbers when querying supply systems. The examples provide steps for applying the supply system transaction screening approach when the supply system provides information in both mass and volume units.

Example A-6: Federal Supply System Transaction Screening When Supply Data Are Available in Mass-Based Units

Step 1: Collect transaction data

Amount of HFC-23 issued from supply system	= 220 lb
Amount of HFC-23 returned to supply system from equipment	= 55 lb

Step 2: Find the difference in the amounts recovered and returned to estimate annual emissions

Equation A-9:
Annual Emissions (MT HFC-23) = (I –R) ● 4.536 x 10^{-4} [MT/lb]
= (220 [lb] – 55 [lb]) ● 4.536 x 10^{-4} [MT/lb]
= 7.48 x 10^{-2} [MT HFC-23]

Where:

I = Amount of F-gas issued from supply system [lb]

R = Amount of F-gas returned to supply system from equipment (includes the amount recovered from equipment during maintenance and the unused amount originally issued from supply) [lb]

Step 3: Convert to MT CO_2e and total emissions

Equation A-10:
CO_2e [MT F-gas] = Annual Emissions [MT] ● F-gas GWP
= 7.48 x 10^{-2} [MT] ● 11,700
= 875.16 [MT CO_2e]

Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

Example A-7: Federal Supply System Transaction Screening When Supply Data Are Available in Volume-Based Units

Step 1: Collect transaction data

Example calculation: The chemical inventory report shows that three canisters of HFC-23 have been issued and returned through the supply system over the past year. The amounts of gas are listed:

Canister number	Gas quantity	CAS Number	Chemical Name	Transaction
3778546	220 lb	75-46-7	Trifluoromethane	Issue
3645585	10 cu ft	75-46-7	Fluoroform	Issue
3654486	55 lb	75-46-7	Trifluoromethane	Return

Step 2: Find the difference in amount recovered and returned

To use the information to calculate emissions, convert the volumetric data to an equivalent mass by obtaining the density of the gas. See the available material safety data sheet (MSDS) information for HFC-23. The gas HFC-23 has a density of 6.59 lb/cu m. In the interest of accuracy and verifiability, always provide the gas density value used for the calculation and its source.

First, convert the volume of HFC-23 consumed to an equivalent mass–based format using recognized conversion factors and the density information from the MSDS.

Total mass of HFC-23 [lb] = volume of gas [cu ft] ● conversion factor [cu m/cu ft] ● density of gas [lb/cu m]
= 10 [cu ft] ● 2.83 x 10^{-2} [cu m/cu ft] ● 6.59 [lb/cu m]
= 1.87 [lb HFC-23]

Step 3: Estimate annual emissions

Equation A-9:
Annual Emissions [MT HFC-23] = (I –R) ● 4.536 x 10^{-4} [MT/lb]
= ((220 [lb] + 1.87 [lb]) – 55 [lb]) ● 4.536 x 10^{-4} [MT/lb]
= 7.57 x 10^{-2} [MT HFC-23]

Where:
I = Amount of F-gas issued from supply system [lb]
R = Amount of F-gas returned to supply system from equipment (includes the amount recovered from equipment during maintenance and the unused amount originally issued from supply) [lb]

Step 4: Convert to MT CO_2e and total emissions

Equation A-10:
CO_2e Emissions [MT F-gas] = Annual Emissions [MT] ● F-gas GWP
= 7.57 x 10^{-2} [MT HFC-23] ● 11,700
= 885.69 [MT CO_2e]

Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

A.5.2 Advanced Methodologies (User Calculated)

There are three advanced methodologies that agencies may use to calculate fugitive emissions:

1. Material balance approach
2. Simplified material balance approach
3. Screening approach

Agencies using an advanced methodology may also want to consider the minimum charge size of equipment that will be inventoried. Conducting equipment inventories of many small sealed refrigerant systems, each containing only small quantities of HFCs, may not be an efficient use of resources, given the minor emissions likely result from these systems.

Advanced Methodology 1: The Material Balance Approach

A material balance approach is the most thorough method for determining fugitive F-gas emissions.

Data Sources

This methodology requires detailed information on the type of each F-gas used by your organization and each piece of F-gas-containing equipment operated at the facility level. It requires data on acquisitions, disbursements, inventory, and capacity (Table A-7).

Table A-7: Fugitive F-Gas Data Sources—The Material Balance Approach

Data Element	Preferred Source
F-gas in inventory (storage not equipment) at the beginning of reporting period [lb]	• Purchase records • Maintenance records • Chemical inventory tracking system
F-gas acquisitions during the reporting period [lb][32]	
Total capacity of F-gas in equipment at the beginning of the reporting period [lb]	
F-gas in inventory (storage not equipment) at the end of reporting period [lb]	
F-gas disbursements during reporting period [lb][33]	
Total capacity of F-gas in equipment at the end of the reporting period [lb]	

Calculation Steps

To calculate scope 1 emissions from fugitive F-gas emissions, do the following:

1. Determine the base inventory
2. Calculate changes to the base inventory
3. Calculate the annual emissions

[32] Acquisitions are the sum of all individual F-gases purchased or otherwise acquired during the year, either in storage containers or in equipment. This includes F-gases purchased from producers or distributors, provided by manufacturers or inside equipment, added to equipment by contractors or other service personnel (unless that refrigerant is from the agency's inventory), and returned after off-site recycling or reclamation.
[33] Disbursements are the sum of all F-gases sold or otherwise dispersed during the year, either in storage containers or in equipment. This includes F-gases in containers or left in equipment that is sold, returned to suppliers, or sent off site for recycling, reclamation, or destruction.

4. Convert them to MT CO_2e and total emissions for each facility

Step 1: Determine the base inventory

For each F-gas in use at each facility, determine the quantity of F-gas in storage at the beginning of the year (does not include F-gas contained within equipment) and the quantity in storage at the end of the year.

Step 2: Calculate changes to the base inventory

For each F-gas, determine purchases and other acquisitions,[29] sales and other disbursements,[30] and net change of total equipment capacity for a given F-gas during the year.[34]

Step 3: Calculate the annual emissions

For each F-gas or refrigerant blend, use Equation A-11.

Equation A-11: Annual F-Gas Emissions

Annual Emissions [MT F-gas] =
$(I_B - I_E + P - S + C_B - C_E) \bullet 4.536 \times 10^{-4}$ [MT/lb]

Where:
I_B = Quantity of F-gas in storage at beginning of inventory year [lb]
I_E = Quantity of F-gas in storage at end of inventory year [lb]
P = Sum of all the F-gas acquisitions [lb]
S = Sum of all the F-gas disbursements [lb]
C_B = Total capacity of F-gas in equipment at beginning of inventory year [lb]
C_E = Total capacity of F-gas in equipment at end of inventory year [lb]

Step 4: Convert to MT CO_2e and total emissions for each facility

Use Equation A-12 to convert them to MT CO_2e. (See Table D-13 for the GWP for each gas.) Sum the emissions from each F-gas type.

Equation A-12: Conversion to MT CO_2e

CO_2e [MT F-gas] =
Annual Emissions [MT] ● F-gas GWP

Example A-8: Material Balance

Step 1: Determine the base inventory

[34] The net increase in total full charge of equipment refers to the full and proper charge of the equipment rather than to the actual charge, which may reflect leakage.

Beginning of year storage	= 1367 lb
End of year storage	= 1323 lb
Purchases of HFC-23	= 441 lb
HFC-23 sold (i.e., disbursements)	= 0.0 lb
Total nameplate capacity of HFC-23 equipment retired during the inventory year	= 44 lb
Total nameplate capacity of new HFC-23 in equipment installed during the inventory year	= 22 lb

Step 2: Calculate changes to the base inventory

Step 3: Calculate the annual emissions

Equation A-11:

Annual Emissions (MT HFC) = $(I_B – I_E + P – S + C_B – C_E) \bullet 4.536 \times 10^{-4}$ [MT/lb]
= (1367 [lb] – 1323 [lb] + 441 [lb] + 0.0 [lb] + 44 [lb] – 22 [lb]) ● 4.536×10^{-4} [MT/lb]
= 0.23 [MT HFC-23]

Where:
I_B = Initial quantity of F-gas in storage for the inventory year [lb]
I_E = End quantity of F-gas in storage for the inventory year [lb]
P = Sum of all the F-gas purchased [lb]
S = Sum of all the F-gas sold [lb]
C_B = Total capacity of F-gas in equipment at the beginning of the inventory year [lb]
C_E = Total capacity of F-gas in equipment at the end of the inventory year [lb]

Step 4: Convert to MT CO_2e and total emissions

Equation A-12:

CO_2e emissions [MT F-gas] = Annual Emissions [MT] ● F-gas GWP
= 0.25 [MT] ● 11,700
= 2,925 [MT]

Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

Advanced Methodology 2: The Simplified Material Balance Approach

Description

This methodology is a simplified version of the first advanced methodology.

Data Sources

Table A-8 shows the data by F-gas type agencies will need for this method.

Table A-8: Fugitive F-Gas Data Sources—Simplified Material Balance Approach

Data Element	Preferred Source
F-gas used to charge new equipment (omitted if the equipment has been precharged by the manufacturer) [lb]	• Purchase records • Maintenance records • Chemical inventory tracking system
Total full capacity of the new equipment (omitted if the equipment has been precharged by the manufacturer) [lb]	
Quantity of F-gas used to service equipment [lb]	
Total full capacity of retiring equipment [lb]	
F-gas recovered from retiring equipment [lb]	

Calculation Steps

To calculate scope 1 emissions from fugitive F-gas emissions, do the following:

1. Determine the base inventory
2. Calculate the annual emissions
3. Convert them to MT CO_2e and total emissions

Step 1: Determine the base inventory

Determine the types and quantities of F-gas used at each facility by determining the quantity of F-gas used to charge new equipment and service existing equipment, including types and quantities recovered from retiring equipment. Also, determine the total full capacity of new and retiring equipment.

Step 2: Calculate the annual emissions

For each type of F-gas, determine any emissions from installation, operation, or disposal of equipment. If the reporting entity did not install or dispose of equipment during the reporting year, emissions from these activities should not be included. Using Equation A-13, add emissions from each piece of equipment to get the total emissions.

Equation A-13: Annual F-Gas Emissions

Annual Emissions [MT F-gas] =
$(P_N - C_N + P_S + C_D - R_D) \bullet 4.536 \times 10^{-4}$ [MT/lb]

Where:*
P_N = Purchases of F-gas used to charge new equipment [lb]
C_N = Total full charge of the new equipment [lb]
P_S = Quantity of F-gas used to service equipment [lb]
C_D = Total full charge of retiring equipment [lb]
R_D = F-gas recovered from retiring equipment [lb]

* If no equipment was newly purchased or retired, variables can be omitted.

Step 3: Convert to MT CO_2e and total emissions

Use Equation A-12 to convert the emissions associated with each F-gas to MT CO_2e and total F-gas emissions at each facility.

Example A-9: Simplified Material Balance

Step 1: Determine the base inventory

Purchases of HFC-23	= 1543 lb
Total full charge of the new equipment	= 882 lb
Quantity of HFC-23 used to service equipment	= 441 lb
Total full charge of retiring equipment	= 794 lb
HFC-23 recovered from retiring equipment	= 220 lb

Step 2: Calculate the annual emissions

Equation A-13:

Annual Emissions (MT HFC-23) = $(P_N - C_N + P_S + C_D - R_D) \bullet 4.536 \times 10^{-4}$ [MT/lb]
= (1543 [lb] – 882 [lb] + 441 [lb] + 794 [lb] – 220 [lb]) ● 4.536×10^{-4} [MT/lb]
= 0.76 [MT HFC-23]

Where:
P_N = Purchases of F-gas used to charge new equipment [lb]
C_N = Total full charge of the new equipment [lb]
P_S = Quantity of F-gas used to service equipment [lb]
C_D = Total full charge of retiring equipment [lb]
R_D = F-gas recovered from retiring equipment [lb]

Step 3: Convert to MT CO_2e and total emissions

Equation A-12:

CO_2e Emissions [MT F-gas] = Annual Emissions [MT F-gas] • F-gas GWP
= 0.76 [MT HFC-23] ● 11,700
= 8,892 [MT CO_2e]

Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

Advanced Methodology 3: The Screening Approach[35]

Data Sources

[35] Although this enhanced screening approach would enhance the fidelity of estimates over the default methodology, the fugitive emission estimates are still uncertain.

To use this screening method, an agency must have an inventory of equipment by quantity, equipment category, F-gas type, and total charge capacity (Table A-9).

Table A-9: Fugitive F-Gas Data Sources—Screening Approach

Data Element	Preferred Source
Inventory of equipment by number, equipment category, F-gas type, and total charge capacity [lb]	• Purchase records • Maintenance records • Chemical inventory tracking system
Amount of F-gas in the equipment [lb]	• Same as above
Emission Factor	• See Table D-7

Calculation Steps

To calculate scope 1 emissions from fugitive F-gas emissions, do the following:

1. Determine the base inventory
2. Calculate the annual emissions
3. Convert them to MT CO_2e and total emissions

Step 1: Determine the base inventory

Determine the quantity and types of equipment by equipment category, the types of F-gas used, and the F-gas charge capacity of each piece of equipment.

Step 2: Calculate the annual emissions

For each type of F-gas, determine any emissions from installation, operation, or disposal of equipment. Equation A-14 combines these three sources, as follows:

> *Installation*: ($C_N \bullet k$), where the emissions from installation equal the amount of refrigerant charged into new equipment (C_N) multiplied by assembly losses (k)
>
> *Operation*: ($C \bullet x \bullet T$), where emissions from operation equal the charge capacity (C) multiplied by the annual leak rate (x) and time used (T)
>
> *Disposal*: ($C_D \bullet y \bullet (1 - z)$), where disposal equals the charge capacity being disposed of (C_D) multiplied by the percent capacity remaining (y) and the percent refrigerant removed ($1-z$).

If the reporting entity did not install or dispose of equipment during the reporting year, emissions from these activities should not be included. Use default emission factors provided in Table D-7 by equipment type. Estimate annual emissions of each F-gas type, using Equation A-14.

Equation A-14: Annual F-gas Emissions

Annual Emissions [MT F-gas] =
$((C_N \bullet k) + (C \bullet x \bullet T) + (C_D \bullet y \bullet (1 - z)) \bullet 4.536 \times 10^{-4}$ [MT/lb]

Where:
C_N = Quantity of F-gas charged into the new equipment [lb]*
C = Total full charge capacity of the equipment [lb]
T = Time equipment was in use (such as 0.5 if used only during half the year and then disposed) [yrs]
C_D = Total full charge capacity of equipment being disposed [lb] [36]
k = Installation emission factor [%]
x = Operation emission factor [%]
y = Refrigerant remaining at disposal [%]
z = Recovery efficiency [%]

* If no equipment was added, variables can be omitted.

Step 3: Convert to MT CO_2e and total emissions

Use Equation A-12 to convert them to units of CO_2e and determine the total F-gas emissions. (See Table D-13 for the GWP for each gas.)

Example A-10: Screening

Step 1: Determine the base inventory

Screening sample data for medium and large commercial refrigeration:

Quantity of HFC-23 charged into the new equipment	= 1764 lb
Total full charge of the new equipment	= 882 lb
Time equipment was in use	= 1 yr
Total full charge of equipment being disposed of	= 441 lb
Installation emission factor	= 3% (0.03)
Operating emission factor	= 35% (0.35)
Refrigerant remaining at disposal	= 100% (1.00)
Recovery efficiency	= 70% (0.70)

Step 2: Calculate the annual emissions

Equation A-14:
HFC-23 Emissions [MT] = $((C_N \bullet k) + (C \bullet x \bullet T) + (C_D \bullet y \bullet (1 - z))) \bullet 4.536 \times 10^{-4}$ [MT/lb]
= ((1764 [lb] ● 0.03 + (882 [lb] ● 0.35 ● 1) + (441 [lb] ● 1.00 ● (1-0.70)) ● 4.536×10^{-4} [MT/lb]
= (52.92 [lb] + 308.7 [lb] + 132.3) ● 4.536 x 10–4 [MT/lb]
= 0.2240 [MT HFC-23]

[36] Omit if no equipment was disposed of during the reporting year.

Where:
C_N = Quantity of F-gas charged into the new equipment [lb]
k = Installation emission factor [%]
C = Total full charge (capacity) of the equipment [lb]
x = Operating emission factor [%]
T = Time equipment was in use (such as 0.5 if used only during half the year and then disposed) [yrs]
C_D = Total full charge (capacity) of equipment being disposed [lb]
y = Refrigerant remaining at disposal [%]
z = Recovery efficiency [%]

Step 3: Convert to MT CO_2e and total emissions

Equation A-12:
CO_2e Emissions [MT F-gas] = Annual Emissions [MT F-gas] ● F-gas GWP
= 0.2153 [MT HFC-23] ● 11,700
= 2,519. 01 [MT CO2e]

Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

A.6 Fugitive Emissions: Wastewater Treatment

Description

This category includes emissions from treatment of wastewater generated as a result of operations. Wastewater from domestic (municipal sewage) and industrial sources is treated to remove soluble organic matter, suspended solids, pathogenic organisms, and chemical contaminants. Wastewater treatment plant (WWTP) processes can produce anthropogenic CH_4 and N_2O emissions.

This section focuses solely on calculating the CH_4 and N_2O emissions created by centralized wastewater treatment and septic systems. GHG emissions from other activities related to wastewater treatment are currently not included in the Guidance.

The default methodology requires only data on the population served by the wastewater treatment plant and uses default national averages to determine the treatment processes and operating variables. However, this is not as accurate as the advanced methodology approach, which uses facility-specific wastewater treatment processes and operating variables.[37] Agencies can pursue the advanced method when flow data are known.

[37] Both the minimum required and advanced methodologies are based on EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks* and *LGO Protocol*, Chapter 10. Agencies should be aware that because there is no widely accepted methodology for calculating emissions associated with wastewater treatment and the *LGO Protocol* is not from a federal source. These calculation methodologies may change in future versions of this TSD. See www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/ for the *LGO Protocol*.

A.6.1 Default Methodology (Calculated by GHG Reporting Portal)

Data Sources

The default methodology applies population-based calculations that use national average defaults. The population served includes not only federal employees, but also on-site contractors and visitors who are contributing biological oxygen demand to the treatment stream at the WWTP (Table A-10). The GHG Reporting Portal allows for customization in the number of hours the population is using the system (default is 12 hours).

Table A-10: Wastewater Treatment Default Data Sources

Data Element	Preferred Source	Alternate Source
Type of WWTP	• Default provided	• Wastewater operations division
Population served (includes employees, on-site contractors, and visitors)	• Agency records	• Agency records

The default methodology divides sources of CH_4 and N_2O emissions into six categories (Table A-11). Agencies may use more than one of these processes.

Table A-11: Summary of Wastewater Treatment Emission Sources

GHG source	GHG type	Data Required	Equation
On-site centralized WWTP with anaerobic digestion	Stationary CH_4 emissions	• Population served	A-15
On-site centralized WWTP with nitrification/denitrification	N_2O emissions	• Population served	A-15
On-site centralized WWTP without nitrification/denitrification	N_2O emissions	• Population served	A-17
On-site effluent discharge to rivers and estuaries with and without nitrification/denitrification	N_2O emissions	• Population served	A-18
On-site wastewater treatment lagoons	CH_4 emissions	• Population served	A-19
On-site septic systems	CH_4 emissions	• Population served	A-20

Calculation Steps

1. Determine which wastewater treatment processes are used
2. Calculate emissions from each wastewater treatment process used
3. Sum emissions from all processes

Step 1: Determine which wastewater treatment processes are used

The emissions from WWTPs depend on the wastewater treatment processes used. Agencies should coordinate with their wastewater operations division to determine which of the processes outlined in Table A-11 are part of the agency wastewater treatment operations. The agency enters the population served by each type of process.

Step 2: Calculate emissions from each wastewater treatment process used

The GHG Reporting Portal automatically calculates emissions associated with each process on the basis of population information provided using the default national averages embedded in the GHG Reporting Portal. Agencies may choose to alter certain criteria, such as the number of workdays per year and fraction of time allocated to the facility (the default is 50 percent, or 12 hours).

This section is subdivided into the six processes outlined in Table A-11. Each subsection briefly describes the process and associated calculations performed by the GHG Reporting Portal.

On-Site Centralized WWTP with Anaerobic Digestion

Many agencies use anaerobic digesters to treat excess biosolids produced by the wastewater treatment processes. The process of anaerobic digestion creates CH_4, which is then combusted as a flare. However, these combustion flares are also a source of CH_4 and N_2O emissions. Equation A-15 describes the default methodology in the GHG Reporting Portal. The GHG Reporting Portal also calculates the stationary combustion emissions from flaring. This is calculated according to the methodology in Section A.1 and does not require any additional agency input.

Equation A-15: CH_4 from On-Site Centralized WWTP with Anaerobic Digestion (Population Served Data)

Annual CH_4 emissions [MT] =

(P ● 230 ● 0.5) ● Digester Gas ● F CH_4 ● ρ(CH_4) ● 0.001

Where:

P = Population serviced by the WWTP with anaerobic digesters

230.00 = Conversion factor [workdays/year]

0.5 = Fraction of time allocated to facility (12 hrs)

Digester Gas = Measured standard cubic feet of digester gas produced per capita per day [cu ft/day], default value of 1.0

F CH_4 = Fraction of CH_4 in biogas, default value of 0.65

ρ(CH_4) = Density of CH_4 at standard conditions [kg/cu ft], default value of 0.019

0.001 = Conversion from kg to MT [MT/kg]

Source: EPA, *Inventory of US Greenhouse Gas Emissions and Sinks: 1990 – 2006*, Chapter 8, 8-9 (2008) and *Local Government Operations Protocol (LGO Protocol)*. See www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/.

On-Site Centralized WWTP with or without Nitrification/Denitrification

This section provides equations for calculating N_2O emissions from a centralized WWTP. Agencies with large Federal facilities may maintain and operate such WWTP facilities on site. At the treatment facility, the wastewater is treated to standards that allow for surface water discharge. Some centralized systems have nitrification/denitrification treatment processes, and some do not.[38]

The population served needs to be modified to include contributions from industry if significant industrial contributions of nitrogen are discharged to your municipal treatment system. The equivalent population from industry is calculated on the basis of the total nitrogen discharged by industry to the municipal treatment system, expressed in kg of total nitrogen per day divided by the nitrogen population equivalent of 0.026 kg N/person/day.

This industrial contribution is adjusted for using an equivalent population proxy value that should be added to the domestic populations served by the centralized wastewater treatment system. This adjusted population served number (domestic plus industrial equivalent) is the value agencies should use in Equation A-16 and Equation A-17.

Equation A-16: Fugitive N_2O Emissions from WWTP with Nitrification/Denitrification

Annual N_2O emissions [MT] =
(Ptotal ● 230.00 ● 0.5) ● EF nit/denit ● 10^{-6}

Where:
Ptotal = Total population served by the centralized WWTP adjusted for industrial discharge, if applicable [person]
230.00 = Conversion factor [workdays/year]
0.5 = Fraction of time allocated to facility (12 hrs)
EF nit/denit = Emission factor for a WWTP with nitrification/denitrification [g N_2O/person/day], default value of 0.019
10^{-6} = Conversion from g to MT [MT/g]

Equation A-17: Fugitive N_2O Emissions from WWTP without Nitrification/Denitrification

Annual N_2O emissions [MT] =
(Ptotal ● 230.00 ● 0.5) ● EF w/o nitrification/denitrification ● 10^{-6}

Where:
Ptotal = Total population served by the centralized WWTP adjusted for industrial discharge, if applicable [person]

[38] Equations in this section are adapted for use by agencies from Section 6.3 of the 2006 IPCC Guidelines and Section 8.2 of the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks (1990–2006).

230.00 = Conversion factor [workdays/year]
0.5 = Fraction of time allocated to facility (12 hrs)
EF w/o nit/denit = Emission factor for a WWTP without nitrification/denitrification [g N_2O/person/day], default value of 0.009.
10^{-6} = Conversion from g to MT [MT/g]

Effluent Discharge to Rivers and Estuaries for WWTP with and without Nitrification/Denitrification

If site-specific data are not available, Equation A-18 is used to estimate fugitive N_2O emissions from effluent discharge with or without nitrification/denitrification. The only difference in either calculation is the default value of the plant nitrification/denitrification factor. The GHG Reporting Portal will automatically calculate each type per the population served. The portal assumes the system is aerobic.

Equation A-18: Fugitive N_2O Emissions from Effluent Discharge (Population Served Data)

Annual N_2O emissions [MT] =
(Ptotal ● 230 ● 0.5) ● (NLoad – Nuptake ● BOD_5 load) ● EFeffluent ● 44/28 ● (1 – Fplant nit/denit) ● 0.001

Where:
Ptotal = Population served adjusted for industrial discharge, if applicable [person]
230.00 = Conversion factor [workdays/year]
0.5 = Fraction of time allocated to facility (12 hrs)
NLoad[39]= Per capita nitrogen load [kg N/person/day], default value of 0.26
Nuptake[40] = Nitrogen uptake for cell growth in aerobic system/anaerobic system [kg N/kg BOD_5], default values of 0.05* for aerobic and 0.005* for anaerobic
BOD_5 load = Per capita BOD_5 produced per day [kg BOD_5/person/day], default value of 0.090
EFeffluent = Effluent emission factor [kg N_2O-N/kg sewage-N produced], default value of 0.005
44/28 = Molecular weight ratio of N_2O to N_2
Fplant nit/denit = Fraction of nitrogen removed for the centralized WWTP with nit/denit, default value of 0.7*
or, Fraction of nitrogen removed for the centralized WWTP w/o nit/denit, default value of 0.0[1]
0.001 = Conversion from kg to MT [MT/kg]

*C. P. L. Grady Jr., G. T. Daigger, and H. C. Lim, *Biological Wastewater Treatment*, p. 108–109, 644 2nd edition (1999).

[39] The default total nitrogen load value is derived on the basis of the following default values from EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2006*, Chapter 8, 8–14 and Table 8.11: Average U.S. protein intake (41.9 kg/person-year) x default fraction of N in protein (0.16 kg N/kg protein) x factor for non-consumed protein added to water (1.4)/days per year (365.25) = 0.026 kg N/person/day.
[40] Some of the influent nitrogen is required for microbial growth inherent in aerobic or anaerobic treatment processes. Nitrogen is assimilated by bacteria, which grow and are further managed as biosolids. This assimilation results in lower nitrogen levels in the discharged effluent.

On-Site Wastewater Treatment Lagoons

Treatment lagoons are pond-like bodies of water used to receive, hold, and treat wastewater for a predetermined period. Wastewater is treated aerobically and anaerobically, and the latter generates quantities of CH_4 emissions. Equation A-19 details the process to estimate fugitive CH_4 emissions from wastewater treatment lagoons. Agencies can account for industrial wastewater emissions by adjusting the population served in Equation A-19 to account for the industrial contribution. The industrial-equivalent population is calculated on the basis of the total biological oxygen demand $(BOD)_5$ discharged by industry to the municipal treatment system, expressed in kg of total BOD_5 per day divided by the BOD_5 population equivalent of 0.090 kg BOD_5/person/day.

The industrial-equivalent population is then added to the domestic population served by the centralized wastewater treatment system, and the total population (domestic plus industrial-equivalent) is the value agencies should use in Equation A-19, as appropriate.

Equation A-19: Fugitive CH_4 from Wastewater Treatment Lagoons (Population Served Data)

Annual CH_4 emissions [MT] =

(Ptotal ● 230 ● 0.5) ● BOD_5 load ● (1-F_P) ● Bo ● $MCF_{anaerobic}$ ● $F_{removed}$ ● 365.25 ● 0.001

Where:

P = Population served by lagoons adjusted for industrial discharge, if applicable [person]

230.00 = Conversion factor [workdays/year]

0.5 = Fraction of time allocated to facility (12 hrs)

BOD_5 load = Per capita BOD_5 produced per day (influent to wastewater treatment process) [kg BOD5/person/day], default value of 0.090

F_P = Fraction of BOD_5 removed in primary treatment, if present, default value of 0.3*

Bo = Maximum CH_4-producing capacity for domestic wastewater [kg CH_4/kg BOD5 removed], default value of 0.6

$MCF_{anaerobic}$ = CH_4 correction factor for anaerobic systems, default value of 0.8

$F_{removed}$ = Fraction of lagoon BOD5 removal performance, default value of 1.0

365.25 = Conversion factor [day/year]

0.001 = Conversion from kg to metric ton [metric ton/kg]

* F_P: Tchobanoglous, G., F.L. Burton, and H.D. Stensel, *Wastewater Engineering: Treatment and Reuse*, p. 473, 4th Edition (2003).

On-Site Septic Systems

Septic tanks are usually small-scale treatment systems where wastewater is held in a tank or receptacle while it is being treated. Anaerobic bacteria treat the waste and release CH_4 in the process. If an agency has operational control of septic systems, fugitive CH_4 emissions should be estimated. If site-specific data are not available, emissions from septic systems will be calculated in the GHG Reporting Portal using Equation A-20.

Equation A-20: Fugitive CH_4 from Septic Systems (Population Served Data)

Annual CH_4 emissions [MT] =
Ptotal ● BOD_5 load ● Bo ● MCF_{septic} ● 365.25 ● 0.001

Where:
P = Population served by septic systems [person]
BOD_5 load = Per capita BOD5 produced per day [kg BOD5/person/day], default value of 0.090
Bo = Maximum CH_4-producing capacity for domestic wastewater [kg CH_4/kg BOD5 removed], default value of 0.6
MCF_{septic} = CH_4 correction factor for septic systems, default value of 0.5
365.25 = Conversion factor [day/year]
0.001 = Conversion from kg to MT [MT/kg]

Step 3: Sum emissions from all processes

In this final step, the GHG Reporting Portal will sum the emissions from all processes and apply the appropriate GWP values to calculate total emissions from wastewater treatment in units of CO_2e.

Equation A-21: Wastewater MT CO_2e Emissions

CO_2e Emissions [MT CO_2e] =
(MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

Example A-11: Wastewater Treatment

An agency's wastewater treatment facility combusts digester gas and has a nitrification/denitrification process. The facility serves 10,000 people, and the agency does not have any site-specific data on the facility. The following equations do not include the stationary process of flaring, leading to very different results, which are addressed in one step in the GHG Reporting Portal.

Step 1: Determine which wastewater treatment processes are used

The WWTP uses incomplete combustion of digester gas and nitrification/denitrification.

Step 2: Calculate emissions from each wastewater treatment process used

Equation A-15: CH_4 Emissions from On-Site Centralized WWTP with Anaerobic Digestion
Annual CH_4 emissions [MT] = (P ● 230 ● 0.5) ● Digester Gas ● F CH_4 ● ρ(CH_4) ● 0.001
= (10,000 ● 230 ● 0.5) ● 1.0 ● 0.65 ● 0.019 ● 0.001
= 14.20 [MT CH_4]

Where:
P = Population serviced by the WWTP with anaerobic digesters
230.00 = Conversion factor [workdays/year]
0.5 = Fraction of time allocated to facility (12 hrs)

Digester Gas = Measured standard cubic feet of digester gas produced per capita per day [cu ft/day], default value of 1.0

F CH_4 = Fraction of CH_4 in biogas, default value of 0.65

P(CH_4) = Density of CH_4 at standard conditions [kg/cu ft], default value of 0.019

0.001 = Conversion from kg to MT [MT/kg]

Equation A-16: N_2O Emissions from WWTP with Nitrification/Denitrification

Annual N_2O emissions [MT] = (Ptotal ● 230 ● 0.5) ● EF nit/denit ● 10^{-6}

= (10,000 ● 230 ● 0.5) ● 0.019 ● 10^{-6}

= 0.02185 [MT N_2O]

Where:

Ptotal = Total population served by the centralized WWTP adjusted for industrial discharge, if applicable [person]

230.00 = Conversion factor [workdays/year]

0.5 = Fraction of time allocated to facility (12 hrs)

EF nit/denit = Emission factor for a WWTP with nitrification/denitrification [g N_2O/person/day], default value of 0.019

10^{-6} = Conversion from g to MT[MT/g]

Step 3: Sum emissions from all processes

Equation A-21: Wastewater MT CO_2e Emissions

CO_2e Emissions [MT CO_2e] = (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

= (14.20 ● 21) + (0.02185 ● 310)

= 304.97 [MT CO_2e]

Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

A.6.2 Advanced Methodology (User Calculated)

Data Sources

The advanced methodology requires the data shown in Table A-12 for each WWTP over which the agency has operational control.

Table A-12: Wastewater Treatment Data Sources

Data Element	Preferred Source
Population served	• Agency records
Wastewater treatment processes used	• Wastewater operations division
Digester gas [cu ft/day]	• Wastewater operations division
Fraction of CH_4 in biogas	• Wastewater operations division
BOD_5 load [kg BOD_5/day]	• Wastewater operations division
Fraction of overall BOD_5 removal performance	• Wastewater operations division

N load	• Wastewater operations division

As in the default methodology, sources of CH_4 and N_2O emissions are divided into six categories. Table A-13 shows the sources of CH_4 and N_2O emissions and references the detailed equations agencies should use to calculate emission from each applicable source.

Table A-13: Summary of Wastewater Treatment Emission Sources

GHG Source	GHG Type	Data Required	Equation
On-site centralized WWTP with anaerobic digestion	Stationary CH_4 emissions	• Digester gas [cu ft/day] • Fraction of CH_4 in biogas	A-21
On-site centralized WWTP with nitrification/denitrification	Fugitive N_2O emissions	• Population served	A-22
On-site centralized WWTP without nitrification/denitrification	Fugitive N_2O emissions	• Population served	A-23
On-site effluent discharge to receiving aquatic environments	Fugitive N_2O emissions	• N load [kg N/day]	A-24
On-site wastewater treatment lagoons	Fugitive CH_4 emissions	• BOD_5 load [kg BOD_5/day] • Fraction of overall BOD_5 removal performance	A-25
On-site septic systems	Fugitive CH_4 emissions	• BOD_5 load [kg BOD_5/person/day]	A-26

Calculation Steps

To calculate scope 1 emissions from wastewater treatment, do the following:

1. Determine which wastewater treatment processes are used
2. Calculate emissions from each wastewater treatment process used
3. Sum emissions from all processes

Step 1: Determine which wastewater treatment processes are used

The emissions from WWTPs depend on the wastewater treatment processes used. Agencies should work with their wastewater operations division to determine which of the processes outlined in Table A-13 are relevant to the agency.

Step 2: Calculate emissions from each wastewater treatment process used

Once an agency has identified the wastewater treatment processes it uses, it should calculate emissions associated with each process using the equations referenced in Table A-13. See the default methodology for more detail on each source.

On-Site Centralized WWTP with Anaerobic Digestion

Equation A-21 should be used by agencies that collect measurements of the volume of digester gas (biogas) produced and the fraction of CH_4 in their biogas in accordance with local, state, and Federal regulations or permits or published industry standardized sampling and testing methodologies, such as 40 *Code of Federal Regulations* (CFR) 136, NSPS, APHA, AWWA, WEF, ASTM, and EPA. The conversion factor from day to year can be modified to reflect the agency's usage of the facility. Equation A-21 does not include the stationary combustion from flaring (which is addressed in Appendix A.1), so the calculations below, which illustrate this methodology, would not match those produced in the GHG Reporting Portal.

Equation A-21: Stationary CH_4 from Centralized WWTP with Anaerobic Digestion (Site-Specific Data)

Annual CH_4 emissions [MT] =
Digester Gas ● FCH_4 ● $\rho(CH_4)$ ● 365.25 ● 0.001

Where:
Digester Gas = Measured standard cubic feet of digester gas produced per day [cu ft/day]
F CH_4 = Measured fraction of CH_4 in biogas
P(CH_4) = Density of methane at standard conditions [kg/cu ft], default value of 0.019
365.25 = Conversion factor [day/year]
0.001 = Conversion from kg to MT [MT/kg]

Source: EPA *Inventory of US Greenhouse Gas Emissions and Sinks: 1990 – 2006*, Chapter 8, 8–9 (2008) and *LGO Protocol*. See www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/.

On-Site Centralized WWTP with or without Nitrification/Denitrification

This section provides equations for calculating N_2O emissions from a centralized WWTP. Agencies with large Federal facilities may maintain and operate such WWTP facilities on site. At the treatment facility, the wastewater is treated to standards that allow for surface water discharge. Some centralized systems have nitrification/denitrification treatment processes, and some do not.[41]

Equation A-22: Fugitive N_2O Emissions from WWTP with Nitrification/Denitrification

Annual N_2O emissions [MT] =
Ptotal ● EF nit/denit ● 10^{-6}

Where:
Ptotal = Total population served by the centralized WWTP adjusted for industrial discharge, if applicable [person]

[41] Equations in this section are adapted for use by agencies from Chapter 6.3 of the 2006 IPCC Guidelines and Chapter 8.2 of the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks (1990–2006).

EF nit/denit = Emission factor for a WWTP with nitrification/denitrification [g N_2O/person/year], default value of 7.0
10^{-6} = Conversion from g to MT [MT/g]

Equation A-23: Fugitive N_2O Emissions from WWTP without Nitrification/Denitrification

Annual N_2O emissions [MT] =
Ptotal ● EF w/o nit/denit ● 10^{-6}

Where:
Ptotal = Total population served by the centralized WWTP adjusted for industrial discharge, if applicable [person]
EF w/o nit/denit = Emission factor for a WWTP without nitrification/denitrification [g N_2O/person/year], default value of 3.2
10^{-6} = Conversion from g to MT [MT/g]

Effluent Discharge to Rivers and Estuaries

If significant industrial contributions of nitrogen are discharged to the treatment system used by an agency, the agency should use Equation A-24.

Equation A-24 requires wastewater operators to collect measurements of the average total nitrogen discharged in accordance with local, state and Federal regulations or permits or published industry standardized sampling and testing methodologies (such as 40 CFR 136, NSPS, APHA, AWWA, WEF, ASTM, and EPA).

Equation A-24: Fugitive N_2O Emissions from Effluent Discharge (Site-Specific Data)

Annual N_2O emissions [MT] =
N Load ● EF effluent ● 365.25 ● 0.001

Where:
N Load = Measured average total nitrogen discharge [kg N/day]
EF effluent = Emission factor [kg N_2O-N/kg sewage-N produced], default value of 0.005
365.25 = Conversion factor [day/year]
0.001 = Conversion from kg to MT [MT/kg]

On-Site Wastewater Treatment Lagoons

If significant industrial contributions of BOD_5 are discharged to the treatment lagoons, agencies should use Equation A-25. Equation A-25 requires agencies to collect measurements of the average BOD_5 load, BOD_5 removal in primary treatment upstream of the lagoon (if primary treatment is present), and the fraction of overall lagoon removal performance in accordance

with local, state and Federal regulations or permits or published industry standardized sampling and testing methodologies (such as 40 CFR 136, NSPS, APHA, AWWA, WEF, ASTM, and EPA).

Equation A-25: Fugitive CH_4 from Wastewater Treatment Lagoons (Site-Specific Data)

Annual CH_4 emissions [MT] =

BOD_5 load ● $(1-F_P)$ ● Bo ● $MCF_{anaerobic}$ ● $F_{removed}$ ● 365.25 ● 0.001

Where:

BOD_5 load = Amount of BOD_5 produced per day (influent to wastewater treatment process) [kg BOD_5/day]

F_P = Fraction of BOD_5 removed in primary treatment, if present

Bo = Maximum CH_4-producing capacity for domestic wastewater [kg CH_4/kg BOD_5 removed], default value of 0.6

$MCF_{anaerobic}$ = CH_4 correction factor for anaerobic systems, default value of 0.8

$F_{removed}$ = Fraction of overall lagoon BOD_5 removal performance

0.001 = Conversion from kg to MT [MT/kg]

On-Site Septic Systems

Equation A-26 should be used when measurements of the average BOD_5 load are collected in accordance with local, state, and Federal regulations or permits or published industry standardized sampling and testing methodologies (such as 40 CFR 136, NSPS, APHA, AWWA, WEF, ASTM, and EPA).

Equation A-26: Fugitive CH_4 from Septic Systems (Site-Specific Data)

Annual CH_4 emissions [MT] =

BOD_5 load ● Bo ● MCF_{septic} ● 365.25 ● 0.001

Where:

BOD_5 load = Amount of BOD_5 produced per day [kg BOD_5/day]

Bo = Maximum CH_4-producing capacity for domestic wastewater [kg CH_4/kg BOD_5 removed], default value of 0.6

MCF_{septic} = CH_4 correction factor for anaerobic systems, default value of 0.5

365.25 = Conversion factor [day/year]

0.001 = Conversion from kg to MT [MT/kg]

Step 3: Sum emissions from all processes

Agencies should sum the emissions from all processes and apply the appropriate GWP values to calculate total emissions from wastewater treatment in units of CO_2e.

Equation A-27: Wastewater MT CO_2e Emissions

CO_2e Emissions [MT CO_2e] = (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

A.7 Fugitive Emissions: Landfills and Solid Waste Facilities

Description

This category includes emissions from the disposal and treatment of municipal solid waste (MSW) generated as a result of agency operations. This category does not include construction and demolition wastes. Disposal of waste (landfilling, incineration) may result in potentially significant GHG emissions. Landfilling organic waste causes anaerobic decomposition and CH_4 generation. If this landfill gas (LFG) is subsequently combusted, the combustion constitutes disposal and releases CO_2 emissions.

The agency can choose to use site-specific data from its waste operations division in the advanced method.

A.7.1 Default Methodology (User Calculated by LandGEM)

Data Sources

The default approach for calculating solid waste emissions is based on both the EPA's Landfill Gas Emissions Model (LandGEM)[42] and the calculations behind the EPA's Climate Leader's Offset Project Methodology. The EPA's LandGEM[1] is well established for regulatory reporting purposes. Agencies may find that their facilities have already calculated their respective CH_4 emissions. However, if not, the Microsoft Excel–based LandGEM requires agencies to enter the requisite data and automatically estimates the emission rates for total landfill gas, CH_4, CO_2 (biogenic), non-methane organic compounds, and individual air pollutants from municipal solid waste landfills. This model does not consider emission reductions from LFG capture.

The GHG Reporting Portal assumes 50 percent of landfills include LFG collection systems. The user calculates the mass of CH_4 and biogenic CO_2 using LandGEM. The agency will need data on the mass of solid waste disposed of and landfill open year and close year for LandGEM. Table A-14 shows the data sources.

Table A-14: Scope 1 Fugitive Emissions from Landfills/Municipal Solid Waste

Data Element	Preferred Source
Mass of solid waste disposed	Reporting to Office of the Federal Environmental Executive (OFEE) under EO 13514, Sec. 2(e)

[42] See www.epa.gov/ttn/catc/dir1/landgem-v302.xls for the EPA LandGEM model. See www.epa.gov/ttncatc1/dir1/landgem-v302-guide.pdf for the LandGEM user guide.

Landfill open year and close year		Wastewater operations division
Mass of biogenic CO_2 and CH_4 [MT (Mg)]*		Calculated by LandGEM or supplemented from Title 5 permit data
Methane concentration rate, k		Default provided by GHG Reporting Portal
Potential methane generation capacity, Lo		Default provided by GHG Reporting Portal
NMOC concentration, ppmv		Default provided by GHG Reporting Portal
Methane content of LFG, % by volume		Default provided by GHG Reporting Portal
Does the landfill have a LFG collection system?		GHG Reporting Portal assumes 50% include LFG collection system
If LFG collection system	Efficiency of LFG collection system	Default provided by GHG Reporting Portal
	Oxidation factor	Default provided by GHG Reporting Portal

*1 MT = 1 Mg (megagram)

Calculation Steps[43]

Landfill fugitive emission can be calculated using the following steps:

1. Use EPA's LandGEM to calculate the CH_4 and CO_2 generation and input into GHG Reporting Portal
2. Calculate emissions from municipal solid waste landfills

Step 1: Use EPA's LandGEM to calculate the CH_4 and CO_2 generation and input into GHG Reporting Portal

The LandGEM requires agency users to input the annual deposition of solid waste and landfill open year and its year of closure (if applicable). The model provides default values for methane concentration rate, potential methane generation capacity, non-methane organic compounds (NMOC) concentration, and methane content of LFG.

The agency should input the mass of solid waste disposed, landfill open and close date, and the mass of CH_4 and CO_2 determined by LandGEM into the GHG Reporting Portal.

LandGEM calculates how the deposition of waste in the landfill will result in anthropogenic CH_4 and biogenic CO_2 emissions over time. Although the emissions from one year's solid waste disposal generates GHGs for several years, the limits of the agencies scope 1 GHG inventories necessitate that only the facility's annual emissions be included in scope 1 for that fiscal year's GHG inventory. This is consistent with methods used for compliance with CAA Title V reporting, which agencies also use to leverage to obtain, aggregate, and input the required data.

[43] Primary Reference: EPA, Climate Leaders, *Direct Emissions from Municipal Solid Waste Landfilling*, October 2004, and EPA TSD for the Landfill Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases, February 2009.

Step 2: Calculate emissions from municipal solid waste landfills

The federal manager inputs the amount of CH_4 and CO_2 generated determined by LandGEM into the GHG Reporting Portal. The portal applies LFG collection (defaults to 50 percent national average), LFG collection efficiency (assumes 75 percent default), and the methotropic bacteria oxidation factor (assumes 10 percent default).

Equation A-28 does not take into account landfill gas flaring, which is a stationary combustion emission source. Flaring is calculated by the same methodology described in Appendix A.1 and would complete the mass balance of the global estimation approach. The GHG Reporting Portal calculates landfill gas flaring in the same location as fugitive landfill emissions to reduce data input requirements. Equation A-28 applies national average factors based upon information in the EPA Climate Leaders "Greenhouse Gas Inventory Protocol Offset Project Methodology" and covers all operations of the approach, with the exception of flare combustion and venting (1-percent non-combustion stack loss).

Equation A-28: Emissions from Solid Waste Facilities (Default)

CO_2e Emissions [MT] = $((CH_{4gen} \bullet 0.5 \bullet (1 - OX_B)) + (CH_{4gen} \bullet (1 - 0.5) \bullet (1 - \eta_{LFGsystem}) \bullet (1 - OX_B)) \bullet GWP$

Where:

CH_{4gen} = CH_4 generated by landfill, calculated in LandGEM [MT]

0.5 = Percentage of uncontrolled release of CH_4

OX_B = Methotropic Bacteria Oxidation Factor, default value of 0.10

$\eta_{LFGsystem}$ = Efficiency of LFG collection system [%], default value of 0.75

GWP = Global Warming Potential of CH_4, 21

Source: EPA, Climate Leaders, Greenhouse Gas Inventory Protocol Offset Project Methodology.

Example A-12: Solid Waste Management

An agency does not know whether its solid waste facility has an LFG collection system.

Step 1: Use EPA's LandGEM to calculate the CH_4 and CO_2 generation and input into the GHG Reporting Portal

The agency inputs the mass of solid waste they dispose of annually, the facility's open/close dates, and other known factors into the LandGEM. LandGEM outputs that the waste generates 1,000 MT of CH_4 and 1,000 MT of CO_2. As no site-specific data are available, the agency uses available default values.

Reported as biogenic emissions
= 1,000 MT CO2e

Step 2: Calculate emissions from landfills and solid waste facilities

Equation A-28: Emissions from Solid Waste Facilities with Unknown LFG Capture Systems
Reported as scope 1 emissions

CO_2e Emissions [MT] = $((CH_{4gen} \bullet 0.5 \bullet (1 - OX_B)) + (CH_{4gen} \bullet (1 - 0.5) \bullet (1 - \eta_{LFGsystem}) \bullet (1 - OX_B)) \bullet GWP$
= $((1{,}000 \bullet 0.5 \bullet (1 - 0.10)) + (1{,}000 \bullet (1- 0.5) \bullet (1 - 0.75) \bullet (1- 0.10)) \bullet 21$
= $((1{,}000 \bullet 0.5 \bullet 0.9) + (1{,}000 \bullet 0.5 \bullet 0.25 \bullet 0.9)) \bullet 21$
= $(450 + 112.5) \bullet 21$
= 11,812.5 MT CO_2e

Where:
CH_{4gen} = CH_4 generated by landfill, calculated in LandGEM [MT]
1.0 = Percentage of uncontrolled release of CO_2
0.5 = Percentage of uncontrolled release of CH_4
$\eta_{LFGsystem}$ = Efficiency of LFG collection system [%], default value of 0.75
OX_B = Methotropic Bacteria Oxidation Factor, default value of 0.10
GWP = Global Warming Potential of CH_4, 21

Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

A.7.2 Advanced Methodology (User Calculated by LandGEM)

Data Sources

The advanced methodology also uses LandGEM. For the advanced methodology, the agency should also have data on site-specific methane concentrations, generation capacity, and system efficiency. If the agency is already reporting under EPA's MRR, use this output.

Before performing the calculations, an agency must determine whether the landfills in its operational control have LFG collection systems. If they do not, agencies need only apply the methodology approach outlined in Step 1 in the next section. However, if one or more of the agency's landfills have an LFG collection system, they should apply both Steps 1 and 2 to the respective landfills. If agencies are unsure whether their landfill has an LFG collection system, Step 2 enables the agency to apply a national average factor until more detailed information is available. Table A-15 shows the data sources.

Table A-15: Scope 1 Fugitive Emissions from Landfills/Solid Waste—Advanced

Data Element	Preferred Source
Does the landfill have a LFG collection system?	Waste operations division
Mass of solid waste disposed	Reporting to OFEE under EO 13514, Sec. 2(e)
Landfill open year and close year	Waste operations division
Mass of biogenic CO_2 and CH_4 [MT (Mg)]*	Calculated by LandGEM or supplemented from Title 5 permit data
Methane concentration rate, k	Waste operations division
Potential methane generation capacity, Lo	Waste operations division
NMOC concentration, ppmv	Waste operations division

Methane content of LFG, % by volume		Waste operations division
If LFG collection system	Efficiency of LFG collection system	Waste operations division
	Oxidation factor	Waste operations division

*1 MT = 1 Mg (megagram)

Calculation Steps

Landfill fugitive emission can be calculated using the following steps:

1. Use EPA's LandGEM or other method to calculate the CH_4 and CO_2 generation
2. Calculate emission reductions from capture and combustion of LFG

The calculation steps for the advanced methodology are the same as for the default, except for substituting site-specific information about the landfills.

Equation A-28: Emissions from Solid Waste Facilities (Default)

CO_2e Emissions [MT] = $(CH_{4gen} \bullet CH_{4release} \bullet (1 - OX_B)) + (CH_{4gen} \bullet (1 - CH_{4release}) \bullet (1 - 0.75) \bullet (1 - OX_B))$

Where:

CH_{4gen} = CH_4 generated by landfill, calculated in LandGEM [MT]

1.0 = Percentage of uncontrolled release of CO_2

$CH_{4release}$ = Percentage of uncontrolled release of CH_4 (either 1.0 or 0 depending on presence of LFG-collection system)

$\eta_{LFGsystem}$ = Efficiency of LFG collection system [%] , default value of 0.75

OX_B = Methotropic Bacteria Oxidation Factor, default value of 0.10

GWP = Global Warming Potential of CH_4, 21

Source: Climate Leaders, Greenhouse Gas Inventory Protocol Offset Project Methodology.

A.8 Industrial Process Emissions

Most agencies will not likely to have applicable fugitive emissions beyond those identified above. If the agency owns and/or operates industrial sources of GHG emissions, the following guidelines can be used to calculate associated process emissions. All references to the IPCC 2006 Guidelines are to Volume 3 of those Guidelines, *Industrial Processes and Product Use*.

- Adipic acid production (process N_2O emissions)
  - EPA MRR Technical Support Document: 40 CFR 98, Subpart E
  - IPCC 2006 Guidelines, Volume 3, Chapter 3, Equation 3.8

  - World Resources Institute (WRI)/World Business Council for Sustainable Development (WBCSD), Calculating N_2O Emissions from the Production of Adipic Acid, 2001

- Aluminum production (process CO_2 and PFC emissions)
  - EPA MRR Technical Support Document: 40 CFR 98, Subpart F
  - CO_2: IPCC 2006 Guidelines, Volume 3, Chapter 4, Equations 4.21–4.24
  - PFCs: IPCC 2006 Guidelines, Volume 3, Chapter 4, Equations 4.25–4.27
- Ammonia production (process CO_2 emissions)
  - EPA MRR Technical Support Document: 40 CFR 98, Subpart G
  - IPCC 2006 Guidelines, Volume 3, Chapter 3, Equation 3.3
- Cement production (process CO_2 emissions)
  - EPA MRR Technical Support Document: 40 CFR 98, Subpart H
  - California Air Resources Board, Draft Regulation for the Mandatory Reporting of Greenhouse Gas Emissions, 2008
  - California Climate Action Registry Cement Reporting Protocol, 2005
  - Cement Sustainability Initiative, The Cement CO_2 Protocol: CO_2 Accounting and Reporting Standard for the Cement Industry (2005) Version 2.0
- HCFC-22 production (process HFC-23 emissions)
  - EPA MRR Technical Support Document: 40 CFR 98, Subpart O
  - IPCC 2006 Guidelines, Volume 3, Chapter 3, Equations 3.31–3.33
  - WRI/WBCSD, Calculating HFC-23 Emissions from the Production of HCFC-22, 2001
- Iron and steel production (process CO_2 emissions)
  - EPA MRR Technical Support Document: 40 CFR 98, Subpart Q
  - IPCC 2006 Guidelines, Volume 3, Chapter 4, Equations 4.9–4.11.
- Lime production (process CO_2 emissions)
  - EPA MRR Technical Support Document: 40 CFR 98, Subpart S
  - IPCC 2006 Guidelines, Volume 3, Chapter 2, Equation 2.5–2.7
- Nitric acid production (process N_2O emissions)
  - EPA MRR Technical Support Document: 40 CFR 98, Subpart V
  - IPCC 2006 Guidelines, Volume 3, Chapter 3, Equation 3.6
  - WRI/WBCSD, Calculating N_2O Emissions from the Production of Nitric Acid, 2001
- Particle accelerators (SF_6 emissions)
  - IPCC 2006 Guidelines, Volume 3, Chapter 8, Equation 8.17

- Pulp and paper production (process CO_2 emissions)
  - EPA MRR Technical Support Document: 40 CFR 98, Subpart AA
  - IPCC 2006 Guidelines, Volume 3, Chapter 2, Chapter 2.5
  - International Council of Forest and Paper Associations, Calculation Tools for Estimating Greenhouse Gas Emissions from Pulp and Paper Mills, Version 1.1, 2005
- Refrigeration and air condition equipment manufacturing (process HFC and PFC emissions)
  - EPA Climate Leaders, Direct HFC and PFC Emissions from Manufacturing Refrigeration and Air Conditioning Units, 2003
  - WRI/WBCSD, Calculating HFC and PFC Emissions from the Manufacturing, Installation, Operation and Disposal of Refrigeration & Air-conditioning Equipment (Version 1.0) 2005
  - Semiconductor manufacturing (process PFC and SF_6 emissions) IPCC 2006 Guidelines, Equations 6.7–6.11

Appendix B—Calculating Scope 2 Emissions

Scope 2 emissions are indirect GHG emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling. They are a consequence of activities occurring within the agency's boundaries, but are emitted at sources owned or controlled by another entity.

This section provides calculation methodologies for the following:

- Purchased electricity
- Purchased steam or hot water
- Purchased chilled water
- Electricity, steam, or hot water purchases from a combined heat and power (CHP) facility[44]
- Steam purchases from a MSW waste-to-energy (WTE) facility
- Reductions from RECs[45]

B.1 Purchased Electricity

Description

Purchased electricity is defined as electricity purchased or otherwise brought into the organizational boundary of the agency. Appendix B.1.1 describes the default methodology for calculated emissions from purchased electricity as calculated by the GHG Reporting Portal. This GHG emissions calculation methodology is the only acceptable one for purchased electricity. Appendix B.1.2 describes the alternative data estimation methods for purchased electricity if this activity data are not available.

B.1.1 Default Methodology (Calculated by GHG Reporting Portal)

Data Sources

The default methodology uses purchased electricity data as reported in the FEMP Energy Report and is ideally based on metered electricity consumption. Table B-1 shows the required data elements and sources**.**

Table B-1: Purchased Electricity Default Data Sources

Data Element	Preferred Source
Purchased Electricity [MWh]	• FEMP Energy Report or purchasing records by eGRID subregion

[44] CHP methodology can be used for advanced methodology for estimating the emissions associated with the purchased electricity generated at a waste-to-energy facility.
[45] Note that this appendix also includes a calculation methodology for GHGs associated with RECs because they can be used to reduce scope 2 emissions.

Emission Factor [kg/MWh]	• Standardized emission factors provided in Table D-8

Calculation Steps

The GHG Reporting Portal calculates scope 2 emissions from electricity use. Agencies provide activity data in step 1, and the portal automatically calculates emissions using steps 2 through 4:

1. Determine annual electricity use from all facilities within the agency's operational control
2. Select the appropriate eGRID subregion output emission rate factors that apply to the electricity used
3. Calculate total CO_2, CH_4, and N_2O emissions, and convert them to MT
4. Convert to MT CO_2e and calculate total emissions

Step 1: Determine annual electricity use from all facilities within the agency's operational control

Include electricity use data for all facilities that fit with the definition of operational control provided in Chapter 2 of the main Guidance document. Agencies must report electricity use by the corresponding eGRID subregion. Agencies should refer to the Federal Energy Management Guidance[46] for preferred sources of electricity use data (metered readings or utility bills) and alternate methods for estimating electricity use when metered data are not available (see Appendix B.2.1).

Step 2: Select the appropriate eGRID subregion output emission rate factors that apply to the electricity used

Electricity emission factors represent the amount of GHGs emitted per unit of electricity consumed. They are usually reported in GHG [lb] per MWh or GWh.

The GHG Reporting Portal will choose the appropriate he eGRID subregion output emission rate factors (see Table D-8). These are included in this document to provide a consistent, verifiable basis for emissions calculations. Because emission factors vary by location, agencies should be sure to use the appropriate **subregion-specific factors for each facility**. Because eGRID is updated periodically, the GHG Reporting Portal will use emission rates from the eGRID edition that is closest to the year of their inventory activity data.[47]

Agencies are not expected to retroactively update their inventories with new eGRID output emissions rate factors once the inventory has been submitted to CEQ. (See the end of Chapter 2 and www.epa.gov/egrid for a map of eGRID subregions and a list of output emission rate factors.)

[46] FEMP, Federal Energy Management Guidance. See www1.eere.energy.gov/femp/regulations/guidance.html.
[47] eGRID publishes data regularly but reflects the operational data from power plants from 2-3 years prior. For example, eGRID2007 has year 2005 operational data but is configured to company ownerships and industry structures as of year 2007.

Step 3: Calculate total CO_2, CH_4, and N_2O emissions, and convert them to MT

To determine annual emissions, the GHG Reporting Portal will multiply annual electricity use in MWh (Step 1) by the emission factors for CO_2, CH_4, and N_2O in kg/MWh (Step 2), and convert them to MT.

Equation B-1: Purchased Electricity GHG Emissions

CO_2 Emissions [MT] = Electricity use [MWh] ● CO_2 emission factor [kg CO_2/MWh] ● 0.001 [MT/kg]
CH_4 Emissions [MT] = Electricity use [MWh] ● CH_4 emission factor [kg CH_4/GWh] ● 0.001 [MT/kg] ● 0.001[GWh/MWh]
N_2O Emissions [MT] = Electricity use [MWh] ● N_2O emission factor [kg N_2O/GWh] ● 0.001 [MT/kg] ● 0.001[GWh/MWh]

Step 4: Convert to MT CO_2e and calculate total emissions

The GHG Reporting Portal will convert CH_4 and N_2O into units of CO_2e using the emissions [MT] and the GWP values provided in Table D-13. It will sum the CO_2e emissions of each of the three gases to determine total GHG emissions for scope 2 purchased electricity.

Equation B-2: Conversion to CO_2e and Determination of Total Emissions

CO_2e Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

Transmission and Distribution Losses

If the agency purchases (rather than generates) electricity and transports it through a T&D system that it owns or controls, it should report the emissions associated with T&D losses under scope 2.

End consumers of purchased electricity do not report indirect emissions associated with T&D losses in scope 2 if they do not own or control the T&D operation where the electricity is consumed. If the agency does not own or control the T&D operation, it must estimate these emissions as scope 3 (see Appendix C.2).

Example B-1: Purchased Electricity

An agency with operations in the eGRID subregion SRVC has all the monthly energy statements for the reporting year. The annual electricity use is 30,000 MWh for the facility, based on monthly energy statements.

Step 1: Determine annual electricity use from all facilities within agency's operational control
The electricity use for this facility is 30,000 MWh.

Step 2: Select the appropriate eGRID subregion output emission rate factors that apply to the electricity used
The SRVC subregion output emission rate factors from eGRID are shown below:

CO_2 emission factor = 514.77 [kg/MWh] **N_2O** emission factor = 8.98 [kg/GWh] **CH_4** emission factor = 10.78 [kg/GWh]
Step 3: Calculate total CO_2, CH_4, and N_2O emissions, and convert them to MT
Equation B- 1: Purchased Electricity GHG Emissions **CO_2 Emissions [MT]** = Electricity use [MWh] ● CO_2 emission factor [kg CO_2/MWh] ● 0.001 [MT/kg] = 30,000 [MWh] ● 514.77 [kg CO_2/MWh] ● 0.001 [MT/kg] **= 15,443.1 [MT CO_2]**
CH_4 Emissions [MT] = Electricity use [MWh] ● CH_4 emission factor [kg CH_4/MWh] ● 0.001 [MT/kg] ● 0.001[GWh/MWh] = 30,000 [MWh] ● 8.98 [kg CH_4/GWh] ● 0.001 [MT/kg] ● 0.001[GWh/MWh] **= 0.269 [MT CH_4]**
N_2O Emissions [MT] = Electricity use [MWh] ● N_2O emission factor [kg N_2O/MWh] ● 0.001 [MT/kg] ● 0.001[GWh/MWh] = 30,000 [MWh] ● 10.78 [kg CH_4/GWh] ● 0.001 [MT/kg] ● 0.001[GWh/MWh] **= 0.3234 [MT N_2O]**
Step 4: Convert to MT CO_2e and calculate total emissions
Equation B-2: Purchased Electricity MT CO_2e Emissions **Total Emissions [MT CO_2e]** = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP) = 15,443.1 [MT CO_2] + (0.2694 [MT CH_4] ●21) + (0.3234 [MT N_2O] ●310) **= 15,549.01 [MT CO_2e]**
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

B.1.2 Alternative Data Estimation Methods (User Calculated) [48]

For scope 2 purchased electricity, this section shows alternative methods for calculating the amount of electricity consumed by a Federal agency. The agency can use these alternative data estimation methods if it is unable to determine annual electricity use from preferred sources of electricity use data (see Appendix B.1.1, Step 1). The data values for electricity use calculated through these alternative methods should be input into the GHG Reporting Portal by the user **only** if electricity use cannot otherwise be obtained. The GHG Reporting Portal will use these values to continue the default methodology (Appendix B.1.1, Steps 2 through 4).

These alternative ways of calculating electricity use data are based on estimates and are less accurate than the metered data requirements for FEMP energy reporting. If metered electricity data are unavailable for an agency's buildings or facilities, there are two alternative approaches for estimating electricity use in order to calculate scope 2 purchased electricity emissions:

1. Estimate electricity use based on proxy year data, or
2. Estimate electricity use based on known electricity use at comparable facilities.

[48] The Climate Registry, *Local Government Operations Protocol*, Version 1.0, September 2008.

Alternative Data Estimation Method 1: Proxy Year Data

If purchase records, electricity bills, or meter readings are not available, the agency can estimate electricity use for a facility on the basis of electricity consumed at the building or facility in another year. Typically, this approach is used when data are unavailable for one or a few minor facilities. Generally, it should not be used as a substitute for a significant group of facilities. Agencies should disclose the use of any proxy years in reporting as part of their qualitative statement disclosure (see Chapter 2.1).

Data Sources

Table B-2 shows the data elements and sources.

Table B-2: Purchased Electricity Proxy Year Alternative Data Sources

Data Element	Preferred Source
Electricity use from prior years [kWh]	• FEMP Energy Report • Electricity purchasing records
Heating and cooling degree days	• National Climate Data Center website

Description

The following steps can be taken to estimate the annual electricity use at a facility using proxy year data:

1. Determine the electricity used in each facility in the proxy year
2. Normalize for heating and cooling degree days

Step 1: Determine the electricity used in each facility in the proxy year

The proxy year can be either another calendar year or a fiscal year.

Step 2: Normalize for heating and cooling degree days

Estimate the proportion of electricity used in a year for heating as a percentage of the total electricity consumed and the proportion of annual electricity used in a year for cooling as a percentage of the electricity consumed. This should be based on the increased electricity consumed during winter months and summer months, respectively. Where monthly data are not available, the best recommendation of the facility manager may be used. Then determine annual heating and cooling degree days in the region in the year being estimated and the proxy year. The National Climate Data Center website provides information on the heating and cooling degree days by month and by state.[49]

Normalize for heating and cooling degree days using Equation B-3.

[49] National Climate Data Center. See: www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp#.

Equation B-3: Normalization for Heating and Cooling Degree Days

Estimated Energy Consumed in Inventory Year [kWh]=
[((EP ● Eh)/DHP) ● (DHI/1)] + [((EP ● EC)/DCP) ● (DCI/1)] + [(1 – Eh – EC) ● EP]

Where:
EP = Electricity used in proxy year [kWh)
Eh = Percentage of electricity used for heating [%]
DHP = Heating degree days in the proxy year
DHI = Heating degree days in inventory year
EC = Percentage of electricity used for cooling [%]
DCP = Cooling degree days in the proxy year
DCI = Cooling degree days in inventory year

Source: LGO Protocol. See www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/.

Agencies should input the estimated electricity use calculated from Equation B-3 into the GHG Reporting Portal, which will follow the default methodology to estimate CO_2, CH_4, and N_2O scope 2 emissions from the facility (see Appendix B.1.1).

Alternative Data Estimation Method 2: Comparable Facilities and Square Footage

If total annual electricity consumption data are not available for the current reporting year or previous years, agencies can estimate electricity use on the basis of the size and function of the facility.

Typically, this approach is used when data are unavailable for one or a few minor facilities. It should not be used as a substitute for a significant group of facilities. When reporting, agencies should note the use of any comparable facilities data to ensure full disclosure in the agency's qualitative statement (see Chapter 2.1).

Data Sources

Table B-3 shows the data elements and sources.

Table B-3: Purchased Electricity Comparable Facilities and Square Footage Alternative Data Sources

Data Element	Preferred Source
Size of the facility [sq ft]	• Building Manager
Size [sq ft] and annual electricity use [MWh] of comparable facilities	• Buildings Manager of comparable facilities

Calculation Steps

Use the following steps to estimate the electricity use at the facility:

1. Determine the size of the facility measured in floor area [sq ft]
2. Identify comparable facilities with known annual electricity use and square footage
3. Determine the electricity used per square foot at a comparable facility and estimate the electricity used at the facility

Step 1: Determine the size of the facility measured in floor area [sq ft]

Agencies can obtain this information from the respective building manager or from the agency's Federal Real Property Profile database, as appropriate.

Step 2: Identify comparable facilities with known annual electricity use rates and square footage

If possible, these facilities should be owned or operated by the same agency. The determination of comparability should include consideration of the primary function of the facility (such as office or hospital) and the primary uses of electricity at each facility (such as heating or cooling). Facility age, hours of operation, number of occupants, and the type of heating and cooling systems employed should also be considered.

If electricity consumption for another comparable facility owned or operated by the same agency is not available, consult the U.S. Energy Information Administration's Commercial Building Energy Consumption Survey for average energy use by facility type and region of the country (www.eia.doe.gov/emeu/cbecs).

Step 3: Determine the electricity used per square foot at a comparable facility and estimate the electricity used at the facility

Divide the annual electricity use at the comparable facility by its square footage to obtain a kWh/sq ft coefficient. Then multiply this coefficient by the area of the facility for which electricity use is being estimated.

Equation B-4: Estimated Annual Electricity Use—Square Footage

Coefficient [kWh/sq ft] =
Annual electricity use at comparable facility [kWh] ÷ size of comparable facility [sq ft]

Estimated Electricity Use [kWh] =
Coefficient [kWh/sq ft] ● size of facility being estimated [sq ft]

Agencies should input the estimated electricity use from Equation B-4 into the GHG Reporting Portal, which will follow the default approach to estimate CO_2, CH_4, and N_2O scope 2 emissions and total CO_2e from the facility (see Appendix B.1.1).

B.2 Purchased Steam or Hot Water

Many agencies purchase steam or district heating to provide space heating in the buildings or process heating for industrial needs. Emissions associated with these sources are considered to be indirect. The default methodology below describes the method for calculated emissions from

purchased steam or hot water using the GHG Reporting Portal. The advanced methodology, B.2.2, describes a more detailed method.

B.2.1 Default Methodology (Calculated by GHG Reporting Portal)

Data Sources

Scope 2 GHG emissions from purchased steam and hot water are primarily calculated from metered steam and hot water consumption data and published emission factors. Table B-4 shows the preferred and alternate data sources for calculating scope 2 emissions from steam or hot water use.

Table B-4: Purchased Steam or Hot Water Default Data Sources

Data Element	Preferred Source	Alternate Source
Steam or hot water consumption [kg]	• FEMP Energy Report	• Purchasing records • Maintenance records
Emission factors [kg/MMBtu]	• Standardized emission factors provided in Table D-9	• N/A

Calculation Steps

To calculate scope 2 emissions from purchased steam or hot water, do the following:

1. Determine the annual steam and hot water use from all facilities within an agency's organizational boundary
2. Calculate the appropriate emission factors that apply to the steam and hot water used
3. Determine total annual emissions in MT CO_2e

Step 1: Determine the annual steam and hot water use from all facilities within an agency's organizational boundary

Agencies should begin by calculating the quantity of steam and hot water purchased. If steam purchases are metered and recorded by the agency, those data should be used. Steam and hot water use data should be included for all facilities within an agency's organizational boundary.

Agencies should refer to Federal Energy Management Guidance for preferred sources of steam and hot water data (metered readings or utility bills) and alternate methods for estimating steam and hot water use when metered data are not available.

Step 2: Calculate the appropriate emission factors that apply to the steam and hot water used

Steam and hot water emission factors represent the amount of GHGs emitted per unit of steam and hot water consumed by fuel type. These are usually reported in units of kg of CO_2e per MMBtu of steam or hot water (see Table D-9).

Emission factors depend on the mix of fuel burned to generate purchased steam and hot water.[50] In some cases, obtaining emission factors directly from the supplier may be possible. In cases where this is not possible, the GHG Reporting Portal will calculate emission factors on the basis of steam and hot water being produced by a natural gas boiler (see Table D-2 and Table D-3)

The GHG Reporting Portal will calculate the emission factors for **steam** by dividing the default emission factors for natural gas for CO_2, CH_4, and N_2O by the product of boiler efficiency (default 80 percent),[51] steam production efficiency (75 percent),[52] and distribution loss (1-10 percent).[53,54]

Equation B-5: Steam Emission Factor Calculation

CO_2 Emission Factor of Steam [kg/MMBtu] = Emission factor CO_2 [kg/MMBtu] ÷ (boiler efficiency [%] ● steam production efficiency [%] ● (1-distribution loss [%]))
CH_4 Emission Factor of Steam [kg/MMBtu] = Emission factor CH_4 [kg/MMBtu] ÷ (boiler efficiency [%] ● steam production efficiency [%] ● (1-distribution loss [%))
N_2O Emission Factor of Steam [kg/MMBtu] = Emission factor N_2O [kg/MMBtu] ÷ (boiler efficiency [%] ● steam production efficiency [%] ● (1-distribution loss [%]))

Hot water calculations are similar to those of steam but don't consider the 75 percent steam production efficiency. The GHG Reporting Portal will calculate the emission factor for **hot water** by dividing the emission factor for natural gas (see Tables D-2 and D-3) by the product of boiler efficiency (default 80 percent)[55] and distribution loss (10 percent).[56]

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[50] Within DOE's 1605(b) Program, *Technical Guidelines, Voluntary Reporting of Greenhouse Gases*, a default emission factor for steam and hot water is provided. However, this factor does not break out emissions by GHG gas and combines emissions from both steam and hot water. This technical guidance calculates its own emission factors for both steam and hot water separately.

[51] DOE, Industrial Technology Programs, Energy Use and Loss Footprints, Assumption and Definitions. See www1.eere.energy.gov/industry/program_areas/footprints.html.

[52] eGRID2007 Technical Support Document, EPA. See www.epa.gov/cleanenergy/documents/egridzips/eGRIDwebV1_0_UsersManual.pdf.

[53] During the transmission and distribution of steam and hot water, some portion of the energy will be absorbed by the ambient environment due to imperfect insulation. In addition, the transmission lines are relatively short as steam and hot water cannot be transported over long distances without losing significant thermal energy. Due to the short distances, a separate entity rarely owns and controls the transmission system. Therefore, this is regarded as part of scope 2 as the transmission lines are considered to occur within a facility's operational control.

[54] DOE, Office of Policy and International Affairs, 1605(b) Program, *Technical Guidelines, Voluntary Reporting of Greenhouse Gases (1605(b)) Program* (March 2006) p. 154–156. See www.eia.doe.gov/oiaf/1605/pdf/Appendix%20N.pdf.

[55] DOE EERE, Industrial Technology Programs, Energy Use and Loss Footprints, Assumption and Definitions. See www1.eere.energy.gov/industry/program_areas/footprints.html.

[56] DOE, Office of Policy and International Affairs, 1605(b) Program, *Technical Guidelines, Voluntary Reporting of Greenhouse Gases (1605(b)) Program* (March 2006) p. 154–156. See www.eia.doe.gov/oiaf/1605/pdf/Appendix%20N.pdf.

Equation B-6: Hot Water Emission Factor Calculation

CO_2 Emission Factor of Hot Water [kg/MMBtu] = Emission factor CO_2 [kg/MMBtu] ÷ (boiler efficiency ● (1– distribution loss [%]))
CH_4 Emission Factor of Hot Water [kg/MMBtu] = Emission factor CH_4 [kg/MMBtu] ÷ (boiler efficiency ● (1– distribution loss [%]))
N_2O Emission Factor of Hot Water [kg/MMBtu] = Emission factor N_2O [kg/MMBtu] ÷ (boiler efficiency ● (1– distribution loss [%]))

Step 3: Determine total annual emissions in MT

To determine annual emissions, the GHG Reporting Portal will multiply annual steam and hot water in MMBtu use separately (Step 1) by the emission factors calculated for CO_2, CH_4, and N_2O in kg of CO_2e per MMBtu (Step 2).

Equation B-7: Purchased Steam GHG Emissions

CO_2 Emission [MT CO_2] = Steam use [MMBtu] ● emission factor [kg CO_2/MMBtu] ● 0.001[MT/kg]
CH_4 Emission [MT CH_4] = Steam use [MMBtu] ● emission factor [kg CH_4/MMBtu] ● 0.001[MT/kg]
N_2O Emission [MT N_2O] = Steam use [MMBtu] ● emission factor [kg N_2O/MMBtu] ● 0.001[MT/kg]

Equation B-8: Purchased Hot Water GHG Emissions

CO_2 Emission Factor [MT] = Hot water use [MMBtu] ● emission factor [kg CO_2/MMBtu] ● 0.001[MT/kg]
CH_4 Emission Factor [MT] = Hot water use [MMBtu] ● emission factor [kg CH_4/MMBtu] ● 0.001[MT/kg]
N_2O Emission Factor [MT] = Hot water use [MMBtu] ● emission factor [kg N_2O/MMBtu] ● 0.001[MT/kg]

Step 4: Determine total annual emissions in MT CO_2e

The GHG Reporting Portal will convert the CO_2, CH_4, and N_2O emissions into units of CO_2e by multiplying the total emissions of each gas (in MT) by the GWP values provided in Table D-13. Then, it will sum the CO_2e emissions of each of the three gases to obtain total GHG emissions. The GHG Reporting Portal will complete this calculation for both steam and hot water separately.

Equation B-9: Conversion to CO_2e and Determination of Total Emissions

CO_2e Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

Example B-2: Purchased Steam and Hot Water

A government entity imports steam and hot water at its Nevada facility. After going through utility bills,

the agency determines that it consumed 1,000 MMBtu of steam and 2,000 MMBtu of hot water for the year.

Step 1: Determine the annual steam and hot water use from all facilities within an agency's operational control

Agency facilities used 1,000 MMBtu of steam and 2,000 MMBtu of hot water this year.

Step 2: Obtain or calculate the appropriate emission factors that apply to steam and hot water

Equation B-5 Steam Emission Factor Calculation

CO_2 Emission Factor of Steam [kg CO_2/MMBtu]

= CO_2 emission factor [kg/MMBtu] ÷ (boiler efficiency [%] ● steam production efficiency [%] ● (1- distribution loss [%]))
= 53.02 [kg CO_2/MMBtu] ÷ (0.80 ● 0.75 ● 0.90)
= 98.19 [kg CO_2/MMBtu]

CH_4 Emission Factor of Steam [kg CH_4/MMBtu]

= CH_4emission factor [kg/MMBtu] ÷ (boiler efficiency [%] ● steam production efficiency [%] ● (1- distribution loss [%]))
= 1.0×10^{-3} [kg CH_4/MMBtu] ÷ (0.80 ● 0.75 ● 0.90)
= 1.85×10^{-3} [kg CH_4/MMBtu]

N_2O Emission Factor of Steam [kg N_2O/MMBtu]

= N_2O emission factor [kg/MMBtu] ÷ (boiler efficiency [%] ● steam production efficiency [%] ● (1- distribution loss [%]))
= 1.0×10^{-4} [kg N_2O/MMBtu] ÷ (0.80 ● 0.75 ● 0.90)
= 1.85×10^{-4} [kg N_2O/MMBtu]

Equation B-6: Hot Water Emission Factor Calculation

CO_2 Emission Factor of Hot Water [kg CO_2/MMBtu]

= CO_2 emission factor [kg/MMBtu] ÷ (boiler efficiency [%] ● (1- distribution loss [%]))
= 53.02 [kg CO_2/MMBtu] ÷ (0.80 ● 0.90)
= 73.64 [kg CO_2/MMBtu]

CH_4 Emission Factor of Hot Water [kg CH_4/MMBtu]

= CH_4 emission factor [kg/MMBtu] ÷ (boiler efficiency [%] ● (1- distribution loss [%]))
= 1.0×10^{-3} [kg CH_4/MMBtu] ÷ (0.80 ● 0.90)
= 1.4×10^{-3} [kg CH_4/MMBtu]

N_2O Emission Factor of Hot Water [kg N_2O/MMBtu]

= N_2O emission factor [kg/MMBtu] ÷ (boiler efficiency [%] ● (1- distribution loss [%]))
= 1.0×10^{-4} [kg N_2O/MMBtu] ÷ (0.80 ● 0.90)
= 1.4×10^{-4} [kg N_2O/MMBtu]

Step 3: Determine total annual emissions in MT CO_2e

Equation B-7: Purchased Steam GHG Emissions

CO_2 Emissions [MT CO_2] = Steam use [MMBtu] ● CO_2 emission factor [kg/MMBtu] ● 0.001 [MT/kg]
= 1,000 [MMBtu] ● 98.19 [kg CO_2/MMBtu] ● 0.001 [MT/kg]
= 98.19 [MT CO_2]

CH_4 Emissions [MT CH_4] = Steam use [MMBtu] ● CH_4 emission factor [kg/MMBtu] ● 0.001 [MT/kg]
= 1,000 [MMBtu] ● 1.85×10^{-3} [kg CH_4/MMBtu] ● 0.001 [MT/kg]
= 1.85×10^{-3} [MT CO_4]

N_2O Emissions [MT N_2O] = Steam use [MMBtu] ● N_2O emission factor [kg/MMBtu] ● 0.001 [MT/kg]
= 1,000 [MMBtu] ● 1.85×10^{-4} [kg N_2O/MMBtu] ● 0.001 [MT/kg]
= 1.85×10^{-4} [MT N_2O]

Equation B-8: Purchased Hot Water GHG Emissions
CO_2 Emissions [MT CO_2] = Hot water [MMBtu] ● CO_2 emission factor [kg/MMBtu] ● 0.001 [MT/kg] = 2,000 [MMBtu] ● 73.64 [kg CO_2e/MMBtu] ● 0.001 [MT/kg] **= 147.28 [MT CO_2]**
CH_4 Emissions [MT CH_4] = Hot water ● CH_4 emission factor [kg/MMBtu] ● 0.001 [MT/kg] = 2,000 [MMBtu] ● 1.4 x 10^{-3} [kg CH_4/MMBtu] ● 0.001 [MT/kg] **= 2.8 x 10^{-3} [MT CH_4]**
N_2O Emissions [MT N_2O] = Hot water ● N_2O emission factor [kg/MMBtu] ● 0.001 [MT/kg] = 2,000 [MMBtu] ● 1.4 x 10^{-4} [kg N_2O/MMBtu] ● 0.001 [MT/kg] **= 2.8 x 10^{-4} [MT N_2O]**
Step 4: Determine total annual emissions in MT CO_2e
Equation B-9: Conversion to CO_2e and Determination of Total Emissions
Steam CO_2 Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP) = 98.19 [MT CO_2] +(1.85 x 10^{-3} [MT CH_4] ● 21) + (1.85 x 10-^{4}[MT N_2O] ● 310) **= 98.29 [MT CO_2e]**
Hot Water CO_2 Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP) = 147.28 [MT CO_2] + (2.8 x 10^{-3} [MT CH_4] ● 21) + (2.8 x 10^{-4} [MT N_2O] ● 310) **= 147.43 [MT CO_2e]**
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

B.2.2 Advanced Methodology (User Calculated)

The advanced method of calculating scope 2 purchases of steam and hot water follows the same procedural steps as outlined above in the default methodology. However, in this instance, the agency is able to obtain information from the steam and hot water provider and use factors specific to the plant rather than the defaults. This methodology can be utilized if the actual boiler efficiency and distribution loss is provided by the supplier.

B.3 Purchased Chilled Water

Many agencies purchase chilled water for cooling purposes. Some agencies purchase chilled water generated by a plant or specific equipment owned and operated by another entity. As is the case with electricity and steam purchases, agencies in these circumstances may need to obtain information from their suppliers to estimate the emissions associated with these purchases. If this information is not available, agencies can use default factors to estimate the emissions associated with their purchased chilled water.

B.2.1 Default Methodology (Calculated by GHG Reporting Portal)

Data Sources

Agencies can estimate emissions associated with purchased chilled water by using values for cooling demand, transmission loss adjustment, and coefficient of performance (COP) (Table B-5). Default factor COP values are provided in Table D-10.

Table B-5: Purchased Chilled Water Default Data Sources

Data Element	Preferred Source
Cooling demand [MMBtu or ton-hours]	• FEMP Energy Report
COP	• Default value
Transmission loss adjustment factor	• Default value

Calculation Steps[57]

To calculate scope 2 emissions from purchased chilled water purchases:

1. Estimate the cooling demand
2. Determine the supplier's COP
3. Calculate the cooling plant inputs from energy cooling demand
4. Determine the annual input of electrical energy from all facilities within an agency's operational control
5. Select the appropriate eGRID subregion output emission rate factors that apply to the chilled water used
6. Calculate total CO_2, CH_4, and N_2O emissions, and convert them to metric tons
7. Convert them to MT CO_2e and determine total emissions

Step 1: Estimate the Cooling Demand

Agencies should refer to monthly cooling bills to estimate the yearly cooling demand of the relevant facility. If the supplied cooling is reported in ton-hours of cooling, convert it to MMBtu at the rate of 0.012 MMBtu per ton-hour.

Step 2: Determine the Supplier's COP

COP values vary depending on the type of chiller used by the supplier. Default cooling supplier COP values are provided Table 10. Agencies should choose the correct COP value.

[57] DOE, Office of Policy and International Affairs, 1605(b) Program, *Technical Guidelines, Voluntary Reporting of Greenhouse Gases*, January 2007.

Step 3: Calculate the Cooling Plant Inputs from Energy Cooling Demand

Agencies can estimate the amount of energy input into the cooling system to meet an entity's demand by multiplying the cooling demand and transmission loss[58] adjustment factor (default percentage of loss 10%)[59] then dividing by the COP of the cooling plant. The cooling plant energy input is represented by the following equation:

Equation B-10: Energy Input of Cooling Plant Calculation

Energy Input from the Cooling Plant =

Agency cooling demand [MMBtu] ● transmission loss adjustment factor ÷ COP cooling plant

Step 4: Determine the annual input of electrical energy from all facilities within an agency's operational control

Agencies determine the energy input quantity from the cooling plant and convert it to MWh. Agencies then sum energy input from all relevant facilities.

Step 5: Select the appropriate eGRID subregion output emission rate factors that apply to the chilled water used

The agency should report purchased chilled water by eGRID subregion into the GHG Reporting Portal. The portal will utilize appropriate emission factors for CO_2, CH_4, and N_2O, listed in Appendix D. This default methodology assumes electric driven chiller.

Step 6: Determine the total annual emissions in MT CO_2e

The GHG Reporting Portal will convert the CO_2, CH_4, and N_2O emissions into units of MT CO_2e by multiplying the total emissions of each gas (in metric tons) by the GWP value, included in Table D-13. The GHG Reporting Portal will sum the CO_2e emissions of each of the three gases to obtain total GHG emissions.

Equation B-11: Conversion to CO_2e and Determination of Total Emissions

CO_2e Emissions [MT CO_2e] =
MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

[58] During the transmission and distribution of chilled water will be absorb energy from the environment consequently raising its temperature. The transmission lines that transport chilled water are relatively short as chilled water cannot be transported over long distances. Due to the short distances, there is rarely a separate entity that owns and controls the transmission system. Therefore, this is regarded as part of scope 2 as the transmission lines are considered to occur within a facility's operational control.

[59] The transmission loss factor approach and default are provided by the DOE, Office of Policy and International Affairs, 1605(b) Program, *Technical Guidelines, Voluntary Reporting of Greenhouse Gases (1605(b)) Program* (March 2006), p. 154–156. See www.eia.doe.gov/oiaf/1605/pdf/Appendix%20N.pdf. The transmission loss factor is meant to account for the thermal losses incurred while transmitting the steam, hot water, or chilled water from generation plant to end user facility.

Example B-3: Purchased Chilled Water

After going through utility bills, an agency located in eGRID subregion RFC West determines that it has consumed 320,000 ton hours of cooling (from an absorption chiller) for the entire year.

Step 1: Estimate the Cooling Demand

The agency has consumed 320,000 ton hours of chilled water

Conversion from ton hours to MMBtu
= 320,000 [ton hours] ● 0.012 [MMBtu/ton hour]
= 3,840 [MMBtu]

Step 2: Estimate the Supplier's COP

Default value for absorption chiller = 0.8

Step 3: Calculate the Cooling Plant Inputs from Energy Demand

Equation B-10: Energy Input of Cooling Plant Calculation

Energy Input from Cooling Plant = Agency cooling demand [MMBtu] ● Transmission loss adjustment factor [%] ÷ Cooling plant COP
= 3,840 [MMBtu] ● (1/(1 – 0.10))/0.80)
= 3,840 [MMBtu] ● 1.11/0.80
= 5,328 [MMBtu]

Step 4: Determine the annual input of electrical energy from all facilities within an agency's operational control

The agency converts the energy input from the cooling plant value from Equation B-10 to MWh

Convert to MWh = Electricity input [MMBtu] ● conversion factor [MWh/MMBtu]
= 5,328 [MMBtu] ● 1/3.413 [MWh/MMBtu]
= 5,328 [MMBtu] ÷ 3.413 [MWh]
= 1,561.09 [MWh]

Step 5: Select the appropriate eGRID subregion output emission rate factors that apply to the chilled water

Use eGRID subregion RFC West emission factors for
CO_2 = 697.54 [lb/MWh]
CH_4 = 8.27 [lb/GWh] = 8.27 [lb/GWh] ● 0.001 = 0.00827 [lb/MWh]
N_2O = 11.66 [lb/GWh] = 11.66 [lb/GWh] ● 0.001 = 0.01166 [lb/MWh]

Step 6: Determine the total annual emissions in MT CO_2e

The agency multiplies the energy input in MWh by the emission factor and converts them to MT.

CO_2 Emissions [MT CO_2] = 1561.09 [MWh] ● 697.54 [lb CO_2/MWh] ● 4.53592 × 10^{-4} [MT/lb]
= 493.93 [MT CO_2]

CH_4 Emissions [MT CH_4] = 1561.09 [MWh] ● 0.00827 [lb CH_4/MWh] ● 4.53592 × 10^{-4} [MT/lb]
= 0.00586 [MT CH_4]

N_2O Emissions [MT N_2O] = 1561.09 [MWh] ● 0.01166 [lb N_2O/MWh] ● 4.53592 × 10^{-4} [MT/lb]
= 0.00826 [MT N_2O]

Equation B-12: Conversion to CO_2e and Determination of Total Emissions

CO_2 Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)
= 493.93 [MT CO_2] +(0.005856 [MT CH_4] ● 21) + (0.008256 [MT N_2O] ● 310)

= 493.9276 + 0.122975611 + 2.55949
= 496.61 [MT CO_2e]

Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

B.3.2 Advanced Calculation Methodology (User Calculated)

The advanced methodology for purchased chilled water uses the same equations as the default method, but uses plant- and fuel-specific emission factors to reflect site-specific efficiencies and conditions instead of default emission factors in Table D-10. The advanced methodology also requires that the agency obtain specific information about a cooling plant's COP.

B.4 Purchased Electricity, Steam, or Hot Water from a Combined Heat and Power Facility

Emissions from CHP facilities represent a special case for estimating scope 2 emissions. Because CHP simultaneously produces electricity and heat (steam and hot water), attributing the total GHG emissions to each product stream would result in double counting and not provide proper credit for the inherent efficiency of cogeneration. Thus, when two or more parties receive the energy streams from CHP plants, GHG emissions must be determined and allocated separately for heat production and electricity production. Since the output from CHP results simultaneously in heat and electricity, the agency must determine what "share" of the total emissions is a result of electricity and heat by using a ratio based on the Btu content of heat and/or electricity relative to the CHP plant's total output.

Below are both the default and advanced approaches for calculating scope 2 emissions for heat (steam or hot water) and power purchases from a CHP facility. It is recommended that agencies use advanced methodologies when possible given the overestimation of emissions possible with the default methods.

B.4.1 Default Methodology (Calculated by GHG Reporting Portal)

Data Sources

The default methodology requires only the quantity of electricity, steam, and/or hot water consumed from the local CHP (Table B-6). The use of these simplified methods will likely result in overly conservative emission estimates.

Table B-6: Combined Heat and Power Default Data Sources

Data Element	Preferred Sources
Electricity consumption [MMBtu]	• FEMP Energy Report
Steam and/or Hot Water consumption [MMBtu]	• FEMP Energy Report

Because of the potential for overestimating scope 2 emissions, the default methodology is not recommended if agencies possess sufficient data for use of the advanced methodologies. In the absence of alternative data, the default approaches are built on the assumption that an agency is purchasing electricity and heat from standard, less efficient systems, rather than a CHP.

Default Methodology for Electricity Purchases

If purchased electricity is from a CHP facility, the default methodology for purchased electricity can be used to estimate scope 2 emissions from this source (see Appendix B.1.1). This methodology assumes that an agency is purchasing electricity from the grid. Grid-average electricity may be produced less efficiently than electricity produced at a CHP facility, so this may result in an over-estimation of scope 2 emissions. This methodology should be used if data from the CHP facility are unavailable.

Default Methodology for Steam or Heat Purchases

If an agency purchases steam or district heating from a CHP facility, the methodology in the steam and hot water section can be used to estimate scope 2 emissions from this source (see Appendix B.2.1). This methodology assumes that purchased steam or district heating is from a conventional boiler plant. Conventional boiler plants produce steam and heat less efficiently than CHP facilities, so this will result in an over-estimation of scope 2 emissions. This methodology should be used if the data from the CHP facility is unavailable.

B.4.2 Advanced Methodology (User Calculated)

Data Sources

The recommended advanced methodology for CHP (Advanced Calculation Methodology 1) requires only minimal utility purchase information and existing energy/emission datasets from eGRID to calculate plant-specific emissions. When a plant is not present in eGRID, advanced method 2 requires additional Federal facility and utility CHP provider coordination to obtain the same energy, emissions, and allocation data. Table B-7 shows the required data and sources for both methods.

Table B-7: Combined Heat and Power Advanced Data Sources

Data Element	Preferred Source
Advanced Calculation Methodology 1: CHP Facilities Present in eGRID	
CHP identity	• Federal facility energy manager
Electricity use [MMBtu]	• FEMP Energy Report
Steam or hot water [MMBtu]	• FEMP Energy Report
Emission factors	• eGRID plant data file
Plant energy input, CHP adjustment, and emissions	• eGRID plant data file
Advanced Calculation Methodology 2: CHP Facilities Not Present in eGRID	
Emissions based on fuel [MT]	• Fuel use data

Data Element	Preferred Source
Total electricity production from the CHP plant [MMBtu]	• Generation and meter readings
Net heat production from the CHP plant [MMBtu]	• Heat content values for steam at different temperature and pressure conditions
Emission factor	• Appendix D

Advanced Calculation Methodology 1: CHP Facilities Present in eGRID

To calculate emissions from heat and power purchases from a CHP facility that is present in eGRID:

1. Determine annual CHP-provided purchased electricity, steam, and/or hot water used at all facilities within agency's operational control
2. Identify and select the appropriate emission factors that apply to the CHP electricity purchased
3. Identify, calculate, and select the appropriate emission factors that apply to the steam purchased
4. Identify, calculate, and select the appropriate emission factors that apply to the hot water purchased
5. Calculate the total annual emissions in metric tons of CO_2, CH_4, and N_2O
6. Determine the total annual emissions in MT CO_2e

Step 1: Determine annual CHP-provided purchased electricity, steam, and/or hot water use from all facilities within agency's operational control

Electricity, steam, and/or hot water use data should be included for all facilities that fit with the definition of operational control provided in Chapter 2 of the main Guidance document. This should align with the agency's annual energy consumption reporting to the FEMP. Agencies should refer to Federal Energy Management Guidance[60] for preferred sources of electricity use data (metered readings or utility bills) and alternate methods for estimating electricity use when metered data are not available.

Step 2: Identify and select the appropriate emission factors that apply to the CHP electricity purchased

Agencies should use the eGRID CHP plant output emission rate factors corresponding to the year of their inventory activity data. As with standard grid provided electricity, agencies are not expected to retroactively update their inventories with new eGRID output emission rate factors once the inventory has been submitted to CEQ.

[60] FEMP, Energy Report guidance. See www1.eere.energy.gov/femp/regulations/guidance.html.

The agency should obtain CHP plant-specific data, which is available from the eGRID website, by downloading the most current version of "eGRID Plant, Boiler, and Generator Data Files." This will be an option once the "Plant and Aggregate Files" are downloaded. Find the identified CHP in the plant file using the state and county data elements to simplify the search. Once identified, the CHP specific emission factors are identified in the applicable eGRID data elements:

- Plant Annual CO_2 Output Emission Rate [lb CO_2/MWh] ($PLCO_2RTA$)
- Plant Annual CH_4 Output Emission Rate [lb CH_4/GWh] ($PLCH_4RTA$)
- Plant Annual N_2O Output Emission Rate [lb N_2O/GWh] (PLN_2ORTA)

Step 3: Identify, calculate, and select the appropriate emission factors that apply to the purchased CHP steam

Using the eGRID Plant file and the identified CHP from purchased electricity, the steam emission factors for the specific CHP can be calculated from existing eGRID data elements. The requisite CHP specific eGRID data elements include:

- Plant Unadjusted Annual CO_2 Emissions [short tons] ($UNCO_2$)
- Plant Unadjusted Annual CH_4 Emissions [lb] ($UNCH_4$)
- Plant Unadjusted Annual N_2O Emissions [lb] (UNN_2O)
- Plant Annual CO_2 Emissions [short tons] ($PLCO_2AN$)
- Plant Annual CH_4 Emissions [lb] ($PLCH_4AN$)
- Plant Annual N_2O Emissions [lb] (PLN_2OAN)
- CHP Plant Useful Thermal Output (USETHRMO) [MMBtu]

Equation B-13 should be used to calculate the steam emission factor.

Equation B-13: eGRID CHP Plant Steam Emission Factor Calculation

eGRID CHP Steam Emission Factor [lb CO_2/MMBtu] =

$$[(UNCO_2 - PLCO_2AN) \bullet STLC] \div [(USETHRMO \bullet SP) \bullet (1 - DL)]$$

Where:

$UNCO_2$ = Plant Unadjusted Annual CO_2 Emissions [short tons CO_2]

$PLCO_2AN$ = Plant Annual CO_2 Emissions [short tons CO_2]

STLC = Short-ton-to-lb conversion (2,000) [lb/short ton]

USETHRMO = CHP Plant Useful Thermal Output [MMBtu]

SP = Steam Production Efficiency (75%)

DL = Distribution Loss (10%)

Source: eGRID2007 Technical Support Document, EPA. See www.epa.gov/cleanenergy/documents/egridzips/eGRID2007TechnicalSupportDocument.pdf.

The CH_4 and N_2O emission factors are likewise derived by substituting $UNCH_4$ or UNN_2O for $UNCO_2$ and by substituting $PLCH_4AN$ or PLN_2OAN for $PLCO_2AN$. However, STLC is omitted due to a change from reporting in short tons to lb.

Step 4: Identify, calculate, and select the appropriate emission factors that apply to the hot water purchased

As with steam (Step 3), the hot water emission factors for the specific CHP can be calculated from existing eGRID data elements. The requisite CHP-specific eGRID data elements are the same as those listed under Step 3.

Equation B-14 should be used to calculate the hot water emission factor.

Equation B-14: eGRID CHP Plant Hot Water Emission Factor Calculation

eGRID CHP Hot Water Emission Factor [lb CO_2/MMBtu] =

$[(UNCO_2 – PLCO_2AN) \bullet STLC] \div [USETHRMO \bullet (1 – DL)]$

Where:

$UNCO_2$ = Plant Unadjusted Annual CO_2 Emissions [short tons CO_2]

$PLCO_2AN$ = Plant Annual CO_2 Emissions [short tons CO_2]

STLC = Short-ton-to-lb conversion (2,000) [lb/short ton]

USETHRMO = CHP Plant Useful Thermal Output [MMBtu]

DL = Distribution Loss [%], default value of 10%

Source: eGRID2007 Technical Support Document, EPA. See www.epa.gov/cleanenergy/documents/egridzips/eGRID2007TechnicalSupportDocument.pdf.

Similar to Step 3, the CH_4 and N_2O emission factors are likewise derived by substituting $UNCH_4$ or UNN_2O for $UNCO_2$ and by substituting $PLCH_4AN$ or PLN_2OAN for $PLCO_2AN$. However, STLC is omitted due to a change from reporting in short tons to lb.

Step 5: Determine total annual emissions in MT of GHGs by type of energy

To determine annual emissions, multiply annual electricity, steam, and/or hot water use (Step 1) by the respective emission factors for CO_2, CH_4, and N_2O in lb per MWh (Step 2) or MMBtu (Step 3 and 4).

Equation B-15: Electricity Use GHG Emissions

CO_2 Emissions [MT CO_2] = Electricity use [MWh] ● Emission factor [lb CO_2/MWh] ÷ 2,204.62 [lb/metric ton]
CH_4 Emissions [MT CH_4] = Electricity use [MWh] ● Emission factor [lb CH_4/MWh] ÷ 2,204.62 [lb/metric ton]
N_2O Emissions [MT N_2O] = Electricity use [MWh] ● Emission factor [lb N_2O/MWh] ÷ 2,204.62 [lb/metric ton]

Equation B-16: Purchased Steam Use GHG Emissions

CO_2 Emissions [MT CO_2] = Steam use [MMBtu] ● Emission factor [lb CO_2/MMBtu] ÷ 2,204.62 [lb/metric ton]
CH_4 Emissions [MT CH_4] = Steam use [MMBtu] ● Emission factor [lb CH_4/MMBtu] ÷ 2,204.62 [lb/metric ton]
N_2O Emissions [MT N_2O] = Steam use [MMBtu] ● Emission factor [lb N_2O/MMBtu] ÷ 2,204.62 [lb/metric ton]

Equation B-17: Purchased Hot Water Use GHG Emissions

CO_2 Emissions [MT CO_2] = Hot water use [MMBtu] ● Emission factor [lb CO_2/MMBtu] ÷ 2,204.62 [lb/metric ton]
CH_4 Emissions [MT CH_4] = Hot water use [MMBtu] ● Emission factor [lb CH_4/MMBtu] ÷ 2,204.62 [lb/metric ton]
N_2O Emissions [MT N_2O] = Hot water use [MMBtu] ● Emission factor [lb N_2O/MMBtu] ÷ 2,204.62 [lb/metric ton]

Step 6: Determine total annual emissions in MT CO_2e

The final step is to convert CH_4 and N_2O into units of CO_2e, and multiply total emissions of each gas (in MT) by the GWP value provided in Table D-13. Then, sum the CO_2e emissions of each of the three gases to obtain total GHG emissions.

Equation B-18: Conversion to CO_2e and Determination of Total Emissions

CO_2e Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

Example B-4: Heat and Power Purchases from a Combined Heat & Power Facility

As a notional example, a U.S. Navy facility in New York State directly purchases electric, steam, and hot water from a CHP facility named the Brooklyn Navy Yard Cogeneration Plant. This plant is owned and operated by Olympus Power, LLC. For the purposes of this example, the plant is outside of the U.S. Navy's operational control; the emissions associated with the electricity, steam, and hot water used would be calculated and reported as scope 2 emissions.

Step 1: Access U.S. Navy Facility Report Energy Use

U.S. Navy Purchases from NTC/MCRD Energy CHP	
Electricity	750 [MWh]
Steam	300 [MMBtu]
Hot Water	150 [MMBtu]

Step 2: Locate NTC/MCRD Energy CHP Plant and its Electricity Emission Factors in eGRID

Plant File

CO_2 Emission Factor [lb CO_2/MWh] = PLCO2RTA = 1230.9 [lb CO_2/MWh]
CH_4 Emission Factor [lb CH_4/GWh] = PLCH4RTA = 23.8 [lb CH_4/GWh]
N_2O Emission Factor [lb N_2O/GWh] = PLN2ORTA = 2.3833 [lb N_2O/GWh]

Step 3: Calculate CHP Plant Steam Emission Factors from eGRID

CO_2 Emission Factor [lb/MMBtu]
= [($UNCO_2$ – $PLCO_2AN$) ● STLC] ÷ [(USETHRMO ● SP) ● (1 – DL)]
= [(1,095,258.8 [short tons CO_2] – 1,093,667.6 [short tons CO_2]) ● 2000[lb/short ton]] ÷ [(11,765.4 [MMBtu] ● 0.75) ● (1 – 0.10)]
= [1,591.2 [short tons CO_2] ● 2000 [lb/short ton]] ÷ [8,824.1 [MMBtu] ● 0.90]
= 3,182,400 [lb CO_2] ÷ 7941.7 [MMBtu]
= 400.7 [lb CO_2/MMBtu]

CH_4 Emission Factor [lb CH_4/MMBtu]
= [($UNCH_4$ – PL CH_4AN)] ÷ [(USETHRMO ● SP) ● (1 – DL)]
= [(42,413.1 [lb CH_4] – 42,351.5 [lb CH_4])] ÷ [(11,765.4 [MMBtu] ● 0.75) ● (1 – 0.10)]
= 61.6 [lb CH_4] ÷ [8,824.1 [MMBtu]● 0.90]
= 61.6 [lb CH_4] ÷ 7941.7 [MMBtu]
= 0.00776 [lb CH_4/MMBtu]

N_2O Emission Factor [lb N_2O/MMBtu]
=[(UNN_2O – PLN_2OAN)] ÷ [(USETHRMO ● SP) ● (1 – DL)]
= [(4241.3 [lb N_2O] – 4235.1 [lb N_2O])] ÷ [(11,765.4 [MMBtu]● 0.75) ● (1 – 0.01)]
= 6.2 [lb N_2O] ÷ [8,824.1 [MMBtu] ● 0.90]
= 6.2 [lb N_2O] ÷ 7941.7 [MMBtu]
= 0.00078[lb N_2O/MMBtu]

Step 4: Locate CHP plant and electricity emission factors in eGRID

CO_2 Emission Factor [lb CO_2/MMBtu]
= [($UNCO_2$ – $PLCO_2AN$) ● STLC] ÷ [USETHRMO ● (1 – DL)]
= [(1,095,258.8 [short tons CO_2] – 1,093,667.6 [short tons CO_2]) ● 2000[lb/short ton]] ÷ [11,765.4 [MMBtu] ● (1 – 0.10)]
= [1,591.2 [short tons CO_2] ● 2000 [lb/short ton]] ÷ [11,765.4 [MMBtu]● 0.90]
= 3,182,400 [lb CO_2] ÷ 10,558.9 [MMBtu]
= 301.4 [lb CO_2/MMBtu]

CH_4 Emission Factor [lb CH_4/MMBtu]
= [($UNCH_4$ – PL CH_4AN)] ÷ [USETHRMO ● (1 – DL)]
= [(42,413.1 [lb CH_4] – 42,351.5 [lb CH_4])] ÷ [11,765.4 [MMBtu] ● (1 – 0.10)]
= 61.6 [lb CH_4] ÷ [11,765.4 [MMBtu]● 0.90]
= 61.6 [lb CH_4] ÷ 10,558.9 [MMBtu]
= 0.00583 [lb CH_4/MMBtu]

N_2O Emission Factor [lb N_2O/MMBtu]
= [(UNN_2O – PLN_2OAN)] ÷ [USETHRMO ● (1-DL)]
= [(4241.3 [lb N_2O] – 4235.1 [lb N_2O])] ÷ [11,765.4 [MMBtu] ● (1 – 0.10)]
= 6.2 [lb N_2O] ÷ [11,765.4 [MMBtu] ● 0.90]
= 6.2 [lb N_2O] ÷ 10,558.9 [MMBtu]
= 0.00059 [lb N_2O/MMBtu]

Step 5: Calculate annual emissions in MT of GHGs by type of energy

Equation B-15: Electricity Use GHG Emissions

Electric CO_2 Emissions [MT CO_2] = Electricity use [MWh] ● CO_2 emission factor [lb/MWh] ÷ 2,204.62 [lb/MT] = 750 [MWh] ● 1230.9 [lb CO_2/MWh] ÷ 2,204.62 [lb/MT] = 418.7 [MT CO_2]
Electric CH_4 Emissions [MT CH_4] = Electricity Use [MWh] ● CH_4emission factor [lb/MWh] ÷ 2,204.62 [lb/MT] = 750 [MWh] ● 23.8 [lb CH_4/MWh] ÷ 2,204.62 [lb/MT] = 8.1 [MT CH_4]
Electric N_2O Emissions [MT N_2O] = Electricity use [MWh] ● N_2O emission factor [lb/MWh] ÷ 2,204.62 [lb/MT] = 750 [MWh] ● 2.3833 [lb N_2O/MWh] ÷ 2,204.62 [lb/MT] = 0.81 [MT N_2O]
Equation B-16: Purchased Steam GHG Emissions
Steam CO_2 Emissions [MT CO_2] = Steam use [MMBtu] ● CO_2 emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT] = 300 [MMBtu] ● 400.7 [lb CO_2/MMBtu] ÷ 2,204.62 [MT] = 54.5 [MT CO_2]
Steam CH_4 Emissions [MT CH_4] = Steam use [MMBtu] ● CH_4 emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT] = 300 [MMBtu] ● 0.00776 [lb CH_4/MMBtu] ÷ 2,204.62 [lb/MT] = 0.00106 [MT CH_4]
Steam N_2O Emissions [MT N_2O] = Steam use [MMBtu] ● N_2O emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT] = 300 [MMBtu] ● 0.00078 [lb N_2O/MMBtu] ÷ 2,204.62 [lb/MT] = 0.00011 [MT N_2O]
Equation B-17: Purchased Hot Water GHG Emissions
Hot Water CO_2 Emissions [MT CO_2] = Hot water use [MMBtu] ● CO_2 emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT] = 150 [MMBtu] ● 301.4 (lb CO_2/MMBtu) ÷ 2,204.62 [lb/MT] = 20.5 [MT CO_2]
Hot Water CH_4 Emissions [MT CH_4] = Hot water use [MMBtu] ● CH_4 emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT] = 150 [MMBtu] ● 0.00583 [lb CH_4/MMBtu] ÷ 2,204.62 [lb/MT] = 0.000397 [MT CH_4]
Hot Water N_2O Emissions [MT N_2O] = Hot water use [MMBtu] ● N_2O emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT] = 150 [MMBtu] ● 0.00059 [lb N_2O/MMBtu] ÷ 2,204.62 [lb/MT] = 0.000040 [MT N_2O]
Step 6: Determine Annual Emissions in MT CO_2e ***(such as Steam)***
Equation B-18: Conversion to CO_2e and Determination of Total Emissions = **Electricity CO_2 Emissions [MT CO_2e]** = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP) = 418.7 [MT CO_2] + (8.1 [MT CH_4] ● 21) + (0.81[MT N_2O] ● 310) = 418.7 [MT CO_2] + 170.1 [MT CO_2e] + 251.1 [MT CO_2e] = 469.9 [MT CO_2e]

Steam CO_2 Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP) = 54.5 [MT CO_2] + (0.00106 [MT CH_4] ● 21) + (0.00011 [MT N_2O] ● 310) = 54.4 [MT CO_2] + 0.02223 [MT CO_2e] + 0.0329 [MT CO_2e] = 54.6 [MT CO_2e]
Hot Water CO_2 Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP) = 20.5 [MT CO_2] +(0.000397 [MT CH_4] ● 21) + (0.000040 [MT N_2O] ● 310) = 20.5 [MT CO_2] + 0.00834 [MT CO_2e] + 0.0124 [MT CO_2e] = 20.52 [MT CO_2e]
Total Emissions [MT CO_2e] = Electricity Emissions [MT CO_2e] + Steam Emissions [MT CO_2e] + Hot Water Emissions [MT CO_2e] = 469.9 [MT CO_2e] + 54.6 [MT CO_2e] + 20.52 [MT CO_2e] **= 545.0 [MT CO_2e]**
****Note:** Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

Advanced Calculation Methodology 2: CHP Facilities Not Present in eGRID[61]

The process for estimating scope 2 emissions from the heat and power product streams produced at a CHP facility not present in eGRID involves the following four steps:

1. Obtain total emissions, power, and heat generation information from CHP facility
2. Determine emissions attributable to net heat production[62] and electricity production
3. Calculate emissions attributable to the agency's portion of heat and electricity consumed
4. Convert to units of CO_2e and determine total emissions

Step 1: Obtain emissions and power and heat information from the CHP facility

Obtain the following information from the CHP plant owner or operator to estimate scope 2 GHG emissions:

- Total emissions of CO_2, CH_4, and N_2O from the CHP facility, based on fuel input information
- Total electricity production from the CHP plant, based on generation meter readings
- Net heat production from the CHP plant

[61] EPA, Climate Leaders, *Indirect Emissions from Purchases/Sales of Electricity and Steam*, June 2008.
[62] Net heat production refers to the useful heat that is produced in CHP, minus whatever heat returns to the boiler as steam condensate, as shown in the equation below.

Equation B-19: Net Heat Production Calculation

Net Heat Production [MMBtu]=
Heat of steam export [MMBtu] – heat of return condensate [MMBtu]

Step 2: Determine emissions attributable to net heat production and electricity production

The most consistent approach for allocating GHG emissions in CHP plants is the efficiency method, which allocates emissions of CHP plants between electric and thermal outputs on the basis of the energy input used to produce the separate steam and electricity products. To use this method, obtain the following information:

- The total emissions from the CHP plant
- The total steam (or heat) and electricity production
- The steam (or heat) and electricity efficiency of the facility

Use the following steps to determine the share of emissions attributable to steam (or heat) and electricity production:

Step 2a: Determine the Total Scope 1 Emissions from the CHP System

Calculate total scope 1 GHG emissions using the methods described in Appendix A.

Step 2b: Determine the Total Steam and Electricity Output for the CHP System

To determine the total energy output of the CHP plant attributable to steam production, use published tables that provide heat content values for steam at different temperature and pressure conditions, for example, the Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam published by the International Association for the Properties of Water and Steam. Energy content values multiplied by the quantity of steam produced at the temperature and pressure of the CHP plant yield energy output values in units of MMBtu.

Alternatively, determine net heat (or steam) production (in MMBtu) by subtracting the heat of return condensate [MMBtu] from the heat of steam export (MMBtu). To convert total electricity production from MWh to MMBtu, multiply by 3.413 MMBtu/MWh.

Step 2c: Determine the Efficiencies of Steam and Electricity Production

Identify steam (or heat) and electricity production efficiencies. If actual efficiencies of the CHP plant are not known, use a default value of 80 percent for steam and a default value of 35 percent for electricity. The use of default efficiency values may, in some cases, violate the energy balance constraints of some CHP systems. However, total emissions will still be allocated between the energy outputs. If the constraints are not satisfied, the efficiencies of the steam and electricity can be modified until constraints are met.

Step 2d: Determine the Fraction of Total Emissions Allocated to Steam and Electricity Production

Allocate the emissions from the CHP plant to the steam (or heat) and electricity product streams by using Equation B-20.

Equation B-20: Allocation of CHP Emissions to Steam and Electricity

Step 1: $E_H = \frac{H \cdot e_P \cdot E_T}{P \cdot e_H + H \cdot e_P}$

Where:

E_H = Emissions allocated to steam production

H = Total steam (or heat) output (MMBtu)

e_H = Efficiency of steam (or heat) production

P = Total electricity output (MMBtu)

e_P = Efficiency of electricity generation

E_T = Total direct emissions of the CHP system

EP = Emissions allocated to electricity production

Step 2: $EP = E_T - E_H$

Where:

E_H = Emissions allocated to steam production

E_T = Total direct emissions of the CHP system

EP = Emissions allocated to electricity production

Step 3: Calculate emissions attributable to the agency's portion of heat and electricity consumed

After determining total emissions attributable to heat and electricity production, calculate the agency's portion of heat or electricity consumed, and thus the agency's indirect GHG emissions associated with heat or electricity use. First, obtain electricity and heat consumption information, then use Equation B-21 to calculate the agency's share of emissions, as appropriate.

Equation B-21: Calculation of Indirect Emissions Attributable to Electricity Consumption

Indirect Emissions Attributable to Electricity Consumption [MT] =

Total CHP emissions attributable to electricity production [MT] ● (agency electricity consumption [kWh] ÷ total CHP electricity production [kWh])

Equation B-22: Calculation of Indirect Emissions Attributable to Heat (or Steam) Consumption

Indirect Emissions Attributable to Heat Consumption [MT] =

Total CHP emissions attributable to heat production [MT] ● (agency heat consumption [MMBtu] ÷ CHP net heat production [MMBtu]**)**

Step 4: Convert to units of CO_2e and determine total emissions

Finally, use the GWP values provided in Table D-13 to convert CH_4 and N_2O emissions to units of CO_2e. Sum the emissions of all three gases to determine an agency's total emissions from CHP.

Equation B-23: Combined Heat and Power MT CO_2e Emissions

CO_2e Emissions [MT CO_2e] = CO_2 [MT] + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

B.5 Purchased Steam from a MSW WTE Facility

Description

GHG emissions from MSW WTE facilities represent a special case for estimating scope 2 emissions. WTE plants use MSW as a primary fuel to generate steam through this dual-use energy recovery and waste management application. MSW fuel is comprised of both renewable biomass (such as wood, paper, and food) and nonrenewable materials (such as plastics and tires), so scope 2 and biogenic emissions must be reported separately through the GHG Reporting Portal.

WTE facilities are sometimes built in proximity to Federal facilities to take mutual advantage of long-term steam purchase agreements and to provide a significant portion of the Federal facilities thermal energy requirements. Although MSW-fueled CHPs are accounted for in the EPA's eGRID, WTE plants producing only thermal energy are not subject to or participants in the program. This section provides both a site-specific and a simplified approach for calculating the GHG emissions associated with the steam purchases from MSW-fueled WTE plants. Below are the default and advanced approaches for calculating scope 2 GHG and biogenic CO_2 emissions from MSW fueled WTE generated steam purchases.

B.5.1 Default Methodology (Calculated by GHG Reporting Portal)

Data Sources

Scope 2 GHG emissions from purchased steam generated by a MSW WTE plant can be calculated from the volume of delivered steam (which is metered) and the default or plant-specific emission factors. Table B-8 shows the recommended and alternate activity data and emission factor sources for calculating scope 2 emissions from MSW-fueled steam purchases.

Table B-8: Steam Purchases from MSW WTE Plants Default Data Sources

Data Element	Preferred Source	Alternate Source
Steam or hot water consumption [MMBtu]	• FEMP Energy Report	• Utility purchase records • Maintenance records

Emission factors	• eGRID Derived Default	• MSW WTE Plant Provided

Calculation Steps

If site-specific MSW WTE plant emission factors are not available, agencies may use the default methodology, which uses default emission factors (Table B-9) derived from similar MSW WTE plants captured via eGRID (plants that generate electricity, not steam). The steps that the GHG Reporting Portal will use to calculate scope 2 emissions from MSW-fueled, WTE-delivered steam are identical to those used for the advanced method, except for Step 2.

1. Determine annual delivered steam purchased for use by all facilities within agency's operational control
2. Utilize the most recent eGRID derived emission factors that apply to the delivered steam
3. Determine the total annual emissions in MT for each GHG
4. Determine total annual emissions in MT CO_2e

Table B-9: Indirect Emission Factor Defaults from MSW WTE Purchased Steam Use

Emission Factor	Default Value
CO_2 emissions	350.5 [lb CO_2/MMBtu]
CH_4 emissions	0.1292 [lb CH_4/MMBtu]
N_2O emissions	0.0172 [lb N_2O/MMBtu]
Biogenic CO_2 emissions	385.6 [lb CO_2/MMBtu]

These default emission factors were derived from a sample of similar MSW-fueled WTE plants found in the eGRID2007 Version 1.1 Plant File (Year 2005 Data). These plants were selected because their primary fuel was MSW and they produce only electricity (i.e., no CHPs with apportioned data inputs). Using a similar approach to that outlined in Appendix B.3 "Advanced Calculation Methodology for CHP Facilities Not Present in eGRID" approach, these plants' delivered steam emission factors were calculated using the following extracted eGRID data elements:

- Plant annual heat input [MMBtu] (PLHTIAN)
- Plant unadjusted annual CO_2 emissions [short tons] ($UNCO_2$)
- Plant unadjusted annual CH_4 emissions [lb] ($UNCH_4$)
- Plant unadjusted annual N_2O emissions [lb] (UNN_2O)
- Plant total nonrenewables generation percent (resource mix) [%] (PLTNPR)
- Plant total renewables generation percent (resource mix) [%] (PLTRPR)

Each plant's annual heat input [MMBtu] was converted to delivered steam using standard assumptions for:

- External boiler efficiency (80 percent)[63]
- Steam conversion efficiency (75 percent)[64]
- Distribution loss (10 percent)[65]

Equation B-24 shows the calculation that the GHG Reporting Portal will perform to determine the delivered steam [MMBtu].

Equation B-24: eGRID MSW WTE Delivered Steam

eGRID MSW WTE Delivered Steam [MMBtu] = DS

$$DS = PLHTIAN \bullet BE \bullet SP \bullet (1 - DL)$$

Where:

PLHTIAN = Plant annual heat input [MMBtu]

BE = Boiler efficiency (80%)

SP = Steam production efficiency (75%)

DL = Distribution loss (10%)

DS = Delivered steam [MMBtu]

The eGRID plant unadjusted annual CO_2 emissions [short tons], plant unadjusted annual CH_4 emissions [lb] ($UNCH_4$), and plant unadjusted annual N_2O emissions [lb] (UNN_2O) quantities were used as the numerator and the delivered steam [MMBtu] as the denominators to develop plant specific emission factors for CO_2, CH_4, and N_2O, as shown in Equation B-25.

Equation B-25: eGRID MSW WTE Delivered Steam

eGRID MSW WTE Delivered Steam Emission Factor [lb CO_2/MMBtu] =

$$(UNCO_2 \bullet STLC) \div DS$$

Where:

$UNCO_2$ = Plant unadjusted annual CO_2 emissions [short tons CO_2]

STLC = Short-ton-to-lb conversion (2000) [lb/short ton]

DS = Delivered steam [MMBtu]

[63] DOE, Industrial Technology Programs, Energy Use and Loss Footprints, Assumption and Definitions. See www1.eere.energy.gov/industry/program_areas/footprints.html.
[64] eGRID2007 Technical Support Document, EPA. See www.epa.gov/cleanenergy/documents/egridzips/eGRIDwebV1_0_UsersManual.pdf.
[65] DOE, Office of Policy and International Affairs, 1605(b) Program, *Technical Guidelines, Voluntary Reporting of Greenhouse Gases (1605(b)) Program* (March 2006) p. 154–156. See www.eia.doe.gov/oiaf/1605/pdf/Appendix%20N.pdf.

The GHG Reporting Portal will calculate emission factors for CH_4 and N_2O using the same equation but without the use of lb/ton conversion. However, as eGRID adjusts out all biogenic CO_2 from its emission factors, the biogenic CO_2 emission factor is generated by back calculating each respective plant's total CO_2 emissions and then broken out into the biogenic CO_2 emission portion using Equation B-26.

Equation B-26: eGRID MSW WTE Biogenic CO_2 Factor

eGRID MSW WTE Delivered Steam Emission Factor [lb CO_2 (Biogenic)/MMBtu] =

$$[(UNCO_2 \bullet STLC) \bullet (PLTRPR/PLTNPR)] \div DS$$

Where:

$UNCO_2$ = Plant unadjusted annual CO_2 emissions [short tons CO_2]

STLC = Short-ton-to-lb conversion (2000) [lb/short ton]

PLTNPR = Plant total nonrenewables generation percent (resource mix) [%]

PLTRPR = Plant total renewables generation percent (resource mix) [%]

DS = Delivered steam [MMBtu]

These emission factors were calculated for all 49 of the eGRID MSW WTE plants. The median plant value for anthropogenic CO_2 was identified, and the derived values used as the default emission factors. The eGRID factor derived datasheet used to calculate these values can be obtained by contacting FEMP.

B.5.2 Advanced Methodology (User Calculated)

There is one other detailed calculation methodology for MSW WTE steam purchases, as shown below.

Calculation Steps

To calculate scope 2 emissions from MSW-fueled, WTE-purchased steam, do the following:

1. Determine annual delivered steam purchased for use
2. Obtain the provider plant's most recent emission factors that apply to the delivered steam
3. Determine the total annual emissions in MT for each GHG
4. Determine total annual emissions in MT CO_2e

Step 1: Determine annual delivered steam purchased for use

Purchased steam and hot water use data should be included for all facilities that fit with the definition of operational control provided in Chapter 2 of the main Guidance document. This

should align with the agency's annual energy consumption report to the DOE and maintain consistency with the data used for calculations as outlined in both Appendix B.2 and B.3.

Step 2: Obtain the provider plant's most recent emission factors that apply to the delivered steam

From preliminary Federal GHG inventory experience, local MSW-fueled, WTE thermal plant operators already calculate and maintain records on total fuel input, GHG emission factors, useful heat production, and delivered steam and hot water emission factors. Given the recent release and stringent requirements of the EPA's MRR, these records and calculations are anticipated to become even more robust and available for all covered facilities by the end of calendar year 2010. The recommended source of current emission factors is the local facility's WTE account manager or environmental manager. When obtaining these factors, it is imperative that the agency's representative specifically request non-offset adjusted factors as many providers may already have incorporated offsets into their final consumer emission factors. If they have not calculated these factors, it is possible to work with the provider and use the "Advanced Calculation Methodology for CHP Facilities Not Present in eGRID" detailed in Appendix B.3 by specifying a 100 percent allocation to steam production.

If obtaining (or developing) site-specific emission factors is not possible, use the default emission factors outlined below in the default methodology (see Appendix B.5.1).

Step 3: Determine total annual emissions in MT for each GHG

To determine annual emissions, multiply annual delivered steam in MMBtu (Step 1) by the emission factors for CO_2, CH_4, and N_2O in lb per MMBtu of delivered steam (Step 2). Divide this product by 2,204.62 to convert them to MT.

Equation B-27: Purchased Steam Use GHG Emissions

CO_2 Emissions [MT] = Steam use [MMBtu] ● CO_2 emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT]
CH_4 Emissions [MT] = Steam use [MMBtu] ● CH_4 emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT]
N_2O Emissions [MT] = Steam use [MMBtu] ● N_2O emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT]
Biogenic CO_2 Emissions [MT] = Steam use [MMBtu] ● Biogenic CO_2 emission factor [lb/MMBtu] ÷ 2,204.62 [lb/MT]

Step 4: Determine total annual emissions in MT CO_2e

The final step is to convert the anthropogenic CO_2, CH_4, and N_2O into units of CO_2e by multiplying the total emissions of each gas (in MT) by the GWP value provided in Table D-13. Then, agencies should sum the CO_2e emissions of each of the three gases to obtain total GHG emissions.

Equation B-28: Conversion to CO_2e and Determination of Total Emissions

CO_2e Emissions [MT CO_2e] =
MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

Biogenic CO_2 emissions resulting from MSW WTE–purchased steam should not be added to scope 2 emissions subtotals. These emission quantities are added to a separate biogenic CO_2 emissions subtotal external to the scope 1, 2, and 3 emissions.

Example B-5: Steam Purchases from MSW Waste-to-Energy Plant

A notional NASA facility in Hampton, VA, purchases steam from a local MSW-fueled WTE plant close to its facility to help meet its thermal energy needs.

Step 1: Determine annual delivered steam purchased
The NASA Center's Energy Manager maintains records and bills paid for the purchased steam that are used to generate the facility energy report. For this fiscal year, the total purchased steam delivered and used at the Center is 1,500 MMBtu.

Step 2: *Obtain the provider's most recent emission factors*
After a request is submitted to the MSW WTE steam plant's account manager, the NASA Center is provided with the following emission factors.

Site-Specific MSW WTE Purchased Steam Emission Factors	
CO_2 Emission Factor	320.5 [lb CO_2/MMBtu]
CH_4 Emission Factor	0.1475 [lb CH_4/MMBtu]
N_2O Emission Factor	0.0165 [lb N_2O/MMBtu]
Biogenic CO_2 Emission Factor	390.5 [lb CO_2/MMBtu]

Step 3: Determine total annual emissions for each GHG

Equation B-27: Purchased Steam Use GHG Emissions
Reported as scope 2:

Purchased Steam CO_2 Emissions [MT CO_2] = 1,500 [MMBtu] ● 320.5 [lb CO_2/MMBtu] ÷ 2,204.62 [lb/MT]
= 218.06 [MT CO_2]

Purchased Steam CH_4 Emissions [MT CH_4] = 1,500 [MMBtu] ● 0.1475 [lb CH_4/MMBtu] ÷ 2,204.62 [lb/MT]
= 0.1004 [MT CH_4]

Purchased Steam N_2O Emissions [MT N_2O] = 1,500 [MMBtu] ● 0.0165 [lb N_2O/MMBtu] ÷ 2,204.62 [lb/MT]
= 0.01123 [MT N_2O]

Reported as biogenic:

Purchased Steam Biogenic CO_2 Emissions [MT CO_2]
= 1,500 [MMBtu] ● 390.5 [lb CO_2/MMBtu] ÷ 2,204.62 [lb/MT]
= 265.7 [MT Biogenic CO_2]

Step 4: Determine total annual emissions in MT CO_2e

Equation B-28: Conversion to CO_2e and Determination of Total Emissions =
Steam CO_2 Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

= 218.06 [MT CO_2] + (0.1004 [MT CH_4] ● 21) + (0.01123 [MT N_2O] ● 310) = 218.06 [MT CO_2] + 2.108 [MT CO_2e] + 3.481 [MT CO_2e] **= 223.65 [MT CO_2e]**
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

B.6 Quantifying Emission Reductions from RECs

B.6.1 Default Methodology (Calculated by GHG Reporting Portal)

Federal agencies may reduce their scope 2 emissions from electricity by purchasing energy generated from renewable energy sources, including their renewable energy and environmental attributes embodied in RECs. A REC is a certificate issued when one MWh of electricity is generated and delivered to the grid from a renewable energy source. RECs are generally defined by states and certification organizations to contain the "environmental attributes" of electricity generated from renewable energy sources. This allows REC owners to claim the attributes of renewable energy (such as GHG emissions benefits) when matched with conventional electricity. Buyers can purchase RECs on the basis of the generation resource (such as wind, solar, geothermal), year, and location.

Data Sources

Table B-10 shows the data elements and their sources.

Table B-10: Preferred Data Sources for Calculating RECs

Data Element	Preferred Source
Emission factors	• eGRID derived default
Location of renewable energy generator	• REC or • Supplied by renewable energy supplier
Amount of RECs purchased [MWh]	• REC

Calculation Steps

To calculate scope 2 emission reductions from REC purchases, follow the steps below:

1. Determine emissions normally emitted
2. Estimate emissions reductions
3. Calculate actual reductions

Step 1: Determine emissions normally emitted

Use methodologies above to establish a "baseline" or actual quantity of emissions that would be emitted in the absence of the renewable energy purchases. This is the same as calculating all required scope 2 emissions before RECs.

Step 2: Estimate emission reductions

The procedure used to estimate emission reductions is shown in Equation B-29. Initial estimates of the reductions can be made using assumptions for the amount of renewable energy purchased and the location of the renewable energy facility.

Equation B-29: Emission Reduction Calculation

Emission reduction$_{i,sr}$ = RE_{sr} ● $ERate\_avoided_{i,sr}$

Where:
Emission $reduction_{i,sr}$ = Quantity [lb] of avoided GHG of type *i* in each subregion *sr*
RE_{sr} = Quantity of renewable energy purchased from each eGRID subregion *sr* as distinct from the agency's electricity supplier's system mix of energy resources
$ERate\_avoided_{i,sr}$ = Emission factor for each GHG of type *i* (such as lb CO_2/MWh, lb CH_4/MWh, lb N_2O/MWh) for each eGRID subregion *sr* where the renewable energy generators are located

These emission reductions must then be summed for each GHG and for each eGRID subregion in which the renewable energy generators are located.

Equation B-30: Sum of Emission Reductions by GHG and eGRID Subregion

Inventory adjustment = $\sum$Baseline $emissions_{i,sr} - \sum$Emission $reduction_{i,sr}$

Where:
Inventory adjustment = Number reported as scope 2 emissions
$\sum$Baseline $emissions_{i,sr}$ = Summation of baseline emissions
$\sum$Emission $reduction_{i,sr}$ = Summation of emission reductions

For renewable energy purchased from U.S. generating facilities, the default emission rate for $ERatebaseline_{i,sr}$ is the eGRID non-baseload output emission rate for the eGRID subregions in which the renewable electricity was generated. The most current eGRID non-baseload output emission rates published should be used at the time the inventory adjustment is calculated.

For renewable energy purchased from international renewable facilities, the emission rate used for $ERatebaseline_{i,sr}$ should be a non-baseload emission rate, if available, for the country or region of origin. Otherwise, a system average emission rate should be used. Regional emission rates are preferable if available, but national average rates can also be used for non-U.S. locations. Only international Federal facilities should purchase international renewable energy.

Agencies should use the eGRID non-baseload output emission rate for the eGRID subregions in which the renewable energy was generated.[66] The location of the renewable energy generators from which the renewable energy is sourced should be requested from the renewable energy supplier. This information may not be available from the agency's supplier until after the year has ended. If the generators are located in multiple subregions, the calculation to determine emission reductions should be repeated for each subregion, using the amount of renewable energy purchased from each subregion.

Step 3: Calculate actual reductions

The quantification of actual emission reductions occurs after the renewable energy purchase has been completed and monitored.

[66] The reason for using the non-baseload emission factor is that non-baseload generation is most likely to be displaced by renewable energy generation, while baseload generation would generally be unaffected. The exclusion of baseload generation from the calculation of emission rates is a widely accepted approach internationally.

Appendix C—Calculating Scope 3 Emissions

Scope 3 emissions are indirect emissions not covered by scope 2. They occur as a consequence of agency activities, but originate from sources not controlled by the agency. They are the scope 1 or scope 2 emissions from other agencies or organizations. Refer to Chapter 2 of the main Guidance document for further information on organizational boundaries.

Table C-1 outlines the scope 3 emissions which agencies are required to report in FY 2010 and FY 2011.

Table C-1: Scope 3 Emissions Categories

Required FY 2010 Scope 3 Emission Categories
Federal Employee Business Air Travel
T&D Losses from Purchased Electricity
Contracted Municipal Solid Waste Disposal
Required FY 2011 Scope 3 Emissions Categories
Federal Employee Business Ground Travel
Federal Employee Commuting
Contracted Wastewater Treatment

Agencies may not have access to quality FY 2008 data for some scope 3 emission categories. Per Chapter 5 of the main Guidance document, agencies must use the earliest year for which data are available to include in the FY 2008 base year inventory. For example, if an agency's employee commuting data becomes available in 2011, those emissions should be incorporated into the FY 2008 baseline.

Federal tenants will be required to report GHG emissions from GSA and privately leased facilities in scope 3 beginning in FY 2011, but those methodologies have yet to be developed.

C.1 Federal Employee Business Air Travel

Description

Business air travel includes official business-related travel aboard third-party owned or operated aircraft. For reporting purposes, scope 3 emissions from business air travel are limited to those from the combustion of fuels (such as the fuel consumed by an aircraft), but not the life-cycle emissions associated with fuel production or manufacturing capital equipment and infrastructure (such as the emissions associated with aircraft manufacturing).

This category excludes aircraft owned and leased by the reporting agency as they are captured under scope 1.

C.1.1 Default Methodology (User Calculated with GSA Travel MIS Tool)

Data Sources

The default methodology is the only option presented for business air travel reporting. This approach calculates air travel emissions using GSA's Travel Management Information Service (GSA Travel MIS).[67] This system can calculate emissions for air travel on behalf of all government agencies. Data requirements for the Travel MIS tool is simply the Passenger Name Record (PNR), as indicated in Table C-2. The PNR is the travel record created for each air travel trip. It provides the complete details of a passenger's booking, including itinerary details such as airline, flight number, class of service, and miles traveled.

Table C-2. Air-Travel Default Data Sources

Data Element	Preferred Source
Passenger Name Record (PNR)	• Obtained from the agency's E-Gov Travel Service (ETS) or from their Travel Agency, also called a Travel Management Center (TMC) or Commercial Travel Office (CTO)

Most agencies and commissions currently have air travel data available in GSA Travel MIS and can immediately access the associated GHG emissions for reporting and planning purposes. Agencies that currently do not have their data in GSA Travel MIS can request it within 2 weeks if they use any of the TMCs or ETSs with established data feed capabilities. Federal agencies with TMCs or ETSs that do not yet have a data feed established with GSA may require 4 to 6 weeks before their data are available after request from GSA.

Security

Access to each Federal agency's air travel data is restricted to that agency only. GSA only uses summary data for strategic sourcing purposes, such as to support the City Pair Program negotiations.

A security certification and accreditation (C&A) was successfully completed for the GSA Travel MIS by GSA's Designated Approving Authority. The C&A was completed with the same stringent government requirements adhered to by each of GSA's outsourced ETS vendors.

Reporting Steps

Agencies are required to report business air travel emissions for FY 2008 and FY 2010. Agencies must use the PNR as the data source and the GSA Travel MIS to conduct the GHG emissions calculation. The GSA Travel MIS standardizes the calculation and the reporting of the data, while also providing a tool for planning reductions in emissions. Agencies are required to report their estimated business air travel GHG emissions via the GHG Reporting Portal.

[67] The GSA Travel MIS methodology for calculating air travel emission is based on the TRX Airline Carbon Emissions Calculator, a detailed and well-accepted for calculating air travel emissions.

This is achieved through the following steps.

1. Determine whether the agency PNR data are in GSA Travel MIS
2. Obtain a user name and password for the GSA Travel MIS from GSA
3. Access the GSA Travel MIS
4. Generate the GHG emissions estimate and report

Step 1: Determine whether the PNR data are in GSA Travel MIS

Contact GSA to determine whether the agency's PNR data are already being submitted. GSA can be reached via e-mail, Travel.programs@gsa.gov, or telephone, 888-472-5585.

If PNR data are not already submitted, inform contracted travel vendors that they are to coordinate with GSA to transfer the data to GSA Travel MIS. Some travel vendors may require that the request originate from the contracting officer or contracting officer's technical representative. For other travel vendors, an e-mail providing direction will be sufficient. The communication to the agency's travel vendor can be done using the following:

> [Travel vendor name] is to provide the [Federal agency's name] travel data (see attached for a standard list of data elements) to GSA's third-party data aggregator beginning with travel commencing on 10/1/2007 through the present. [Travel vendor name] must continue to provide the data monthly in accordance with its contractual obligations (as specified in the applicable ETS and/or TSS contracts as either an accommodated TMC or an ETS provider). GSA's data aggregator provides a software program, which will export for the data automatically each month without requiring any staff resources, or [travel vendor name] provides the data using secure FTP.
>
> Note: The standard list of data elements can be provided by GSA.

Step 2: Obtain a user name and password for the GSA Travel MIS from GSA

Contact GSA to establish an account. The user name and password will allow access to the GSA Travel MIS.

Step 3: Access the GSA Travel MIS

Using a web browser, access the https://gsa.traveltrax.com web link and enter login information.

Figure C-1: Login Page for GSA Travel MIS

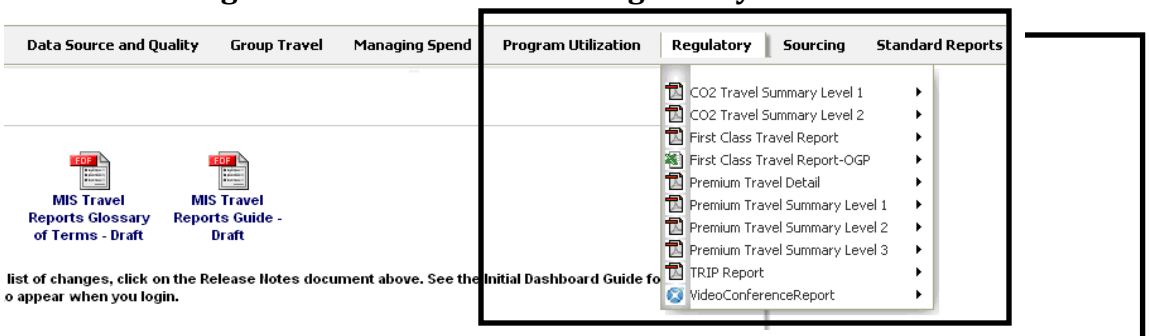
Step 4: Generate the GHG emissions estimate and report

After successfully logging in to the GSA Travel MIS, select the Regulatory tab. There are two GHG emission estimate reports available under that tab:

1. CO_2 Travel Summary Level 1
2. CO_2 Travel Summary Level 2

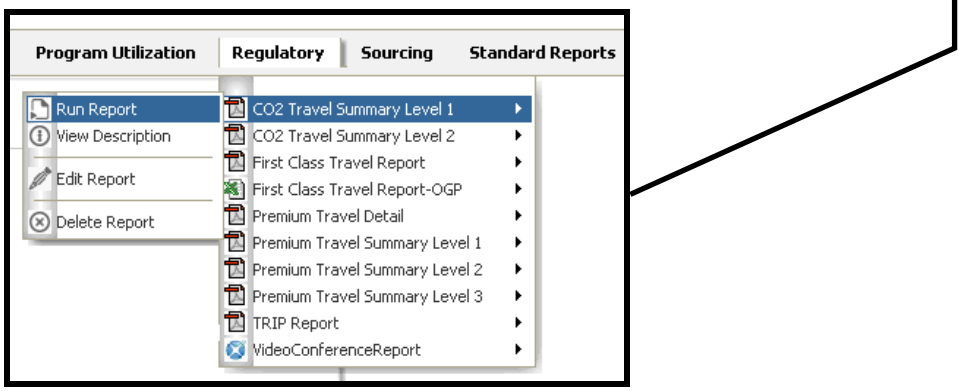
The Level 1 report provides the GHG emissions for the entire agency. Level 2 breaks down emissions data at the second level of the agency's organizational hierarchy. For example, a DoD level 1 report would list total DoD-wide emissions, and the level 2 report would list emissions by the associated services (such as Army, Air Force, Navy, or Marine Corps).[68] The level 2 breakdown is provided at the bureau level on the basis of codes assigned by the U.S. Treasury: www.whitehouse.gov/omb/circulars/a11/current_year/app_c.pdf.

Figure C-2: GSA Travel MIS Regulatory Tab



To run the report, move the cursor to the left and highlight *Run Report*.

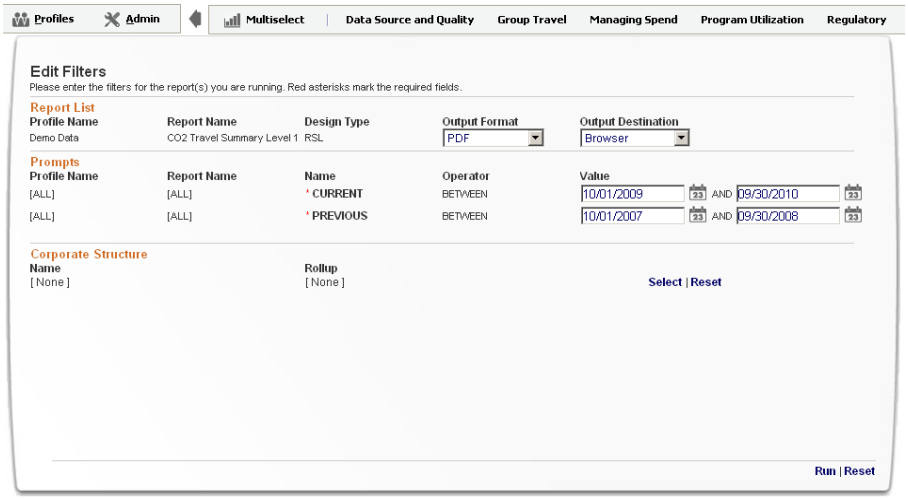
Figure C-3: Running the Report



Enter the dates you wish to report. The following example compares the FY 2008 baseline to the first reporting year of FY 2010. After entering the dates, click *Run* in the lower right corner of the screen, and the GHG emissions estimate report will be generated as a PDF file.

[68] This Level 1/Level 2 breakdown holds for all agencies except the Department of Homeland Security (DHS). For more information on DHS specifics, contact Travel.programs@gsa.gov or telephone 888-472-5585.

Figure C-4: Entering Dates



The following is an example of the Level 1 report.

Figure C-5: Page 1 of the Emissions Report

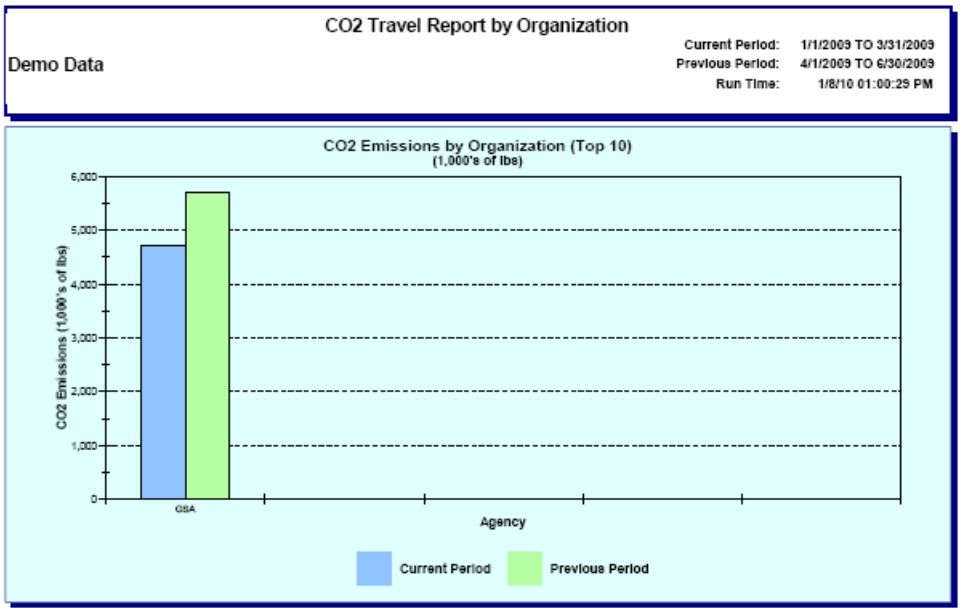


Figure C-6: Page 2 of the Emissions Report

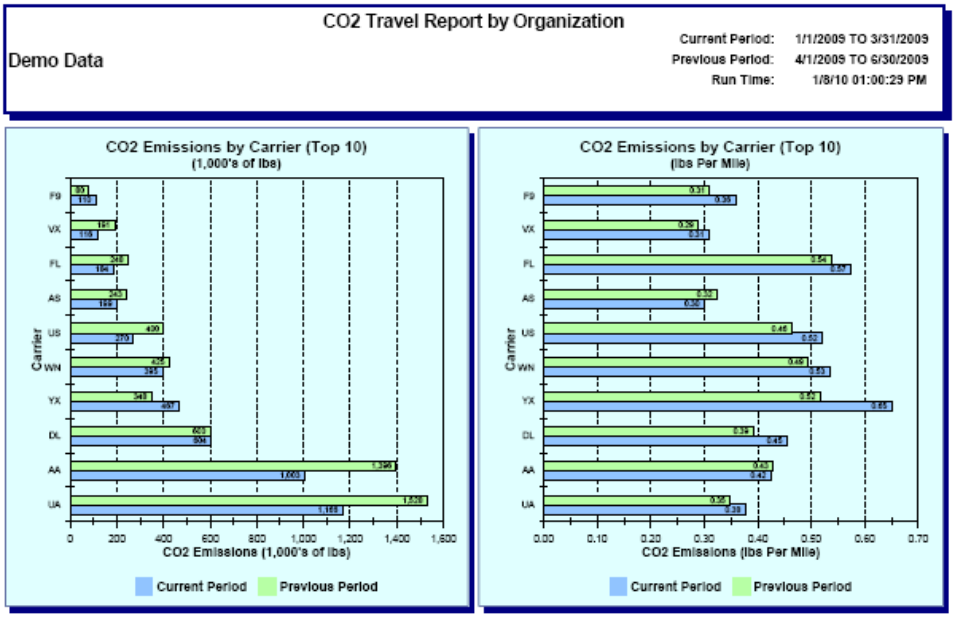


Figure C-7: Page 3 of the Emissions Report

CO2 Travel Report by Organization

Demo Data

Current Period: 1/1/2009 TO 3/31/2009
Previous Period: 4/1/2008 TO 6/30/2009
Run Time: 1/8/10 01:00:29 PM

Agency	O&D Segment Count Curr Period	O&D Segment Count Prev Period	O&D Segment Count Variance	Total CO2 Emissions Curr Period (Pounds)	Total CO2 Emissions Prev Period (Pounds)	Total CO2 Emissions Variance (Pounds)	Average CO2 Emissions Per O&D Segment Curr Period (Pounds)	Average CO2 Emissions Per O&D Segment Prev Period (Pounds)
General Services Administration	14,620	18,232	(3,612)	4,702,606	5,701,578	(998,972)	322	313
Grand Total:	14,620	18,232	(3,612)	4,702,606	5,701,578	(998,972)	322	313

Save the Emissions Report PDF file to your hard disk. Find the total quantity of GHG listed in the GSA Travel MIS report by type. Submit via the GHG Reporting Portal to report the agency's base year FY 2008, FY 2010, and subsequent year business air travel emissions.[69]

Calculation Methodology

GSA's travel tool follows an advanced methodology to calculate the emissions associated with business air travel. Once agencies submit their PNRs, each step in the methodology is performed automatically in the GSA Travel MIS tool using the instruction provided above. **This calculation methodology is only presented for purposes of technical background and**

[69] The GSA Travel MIS has an interactive dashboard that is to be used for monitoring your GHG emissions and can be used to help plan reductions. The dashboard is also under the *Regulatory* tab. This dashboard displays the top 20 city pairs travelled by the agency during the reporting period. The levers on the right allow the user to adjust the trips taken to the most traveled city pairs, which can facilitate an assessment of emission reduction opportunities.

transparency. The GSA Travel MIS tool will automatically complete the calculations. This methodology is outlined below:

Step 1: Calculate the distance traveled for each employee trip

To accurately estimate GHG emissions associated with business air travel trip, the GSA Travel MIS tool must have data on the originating city and destination city, as well as any connecting cities if not a nonstop flight. The requisite data for this operation are found in the reporting agency's PNRs.

Step 2: Determine the fuel burn rate for the aircraft

The amount of GHG emissions is directly related to the amount of fuel burned by aircraft. Different aircraft can burn very different amounts of fuel, so it is important to have detailed information on fuel burn rates. The fuel burn rate per passenger is calculated as fuel burned divided by or apportioned to the number of seats. However, the number of seats must be a weighted average or specific to the actual seat size (varying among the cabin classes) in the plane. Also, the occupancy rate of the seats in each cabin class must be included.

An accurate fuel burn rate is obtained from the 2006 version of the EMEP/CORINAIR Emission Inventory Guidebook (EIG). This dataset provides fuel consumption data for different aircraft by a range of total journey lengths for each of the different fuel-consumption stages: taxi out, take off, climb-out, climb/cruise/descent, approach landing, and taxi in.

Step 3: Calculate CO_2 emissions for the flight[70,71]

To convert from fuel burned to CO_2 emitted, a factor of 3.15 [kg CO_2/kg fuel] is used from the EIG. A conversion factor of 2.20 [lb/kg] is used.

Step 4: Determine the cargo and passenger allocation

Cargo and passenger data has been gathered for U.S. carriers from the U.S. Department of Transportation, Bureau of Transportation Statistics. Cargo includes baggage, freight, mail, and passengers. Passenger and baggage weight is derived from the number of passengers and an industry standard assumption of 100 kg per individual and baggage. The data are provided by carrier, stage (domestic or international), and aircraft type for each carrier.

For each carrier, stage, and equipment type, CO_2 emissions are allocated between cargo and passengers by the percentage of cargo weight to actual payload and the percentage of passenger weight to actual payload.

Step 5: Determine the cabin allocations

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[70] For consistency with scope 1 aircraft estimation methodology, the GSA Travel MIS tool does not currently incorporate radiative forcing into its generation of CO_2e estimates. However, this tool architecture does have the capability to incorporate such provision in the future as the state of the science progresses.

[71] Future iterations of the GSA Travel MIS tool will include an expanded capability to more fully calculate emissions in terms of MT CO_2e.

CO_2 emissions are allocated among cabin classes to obtain a more accurate amount of the space taken by a passenger's seat. The number of seats for a flight is taken from the Schedules database, while the distribution of seats among the various cabins is taken from the Fleet database. Both databases are available from OAG Back Aviation Solutions. Data from www.SeatGuru.com is used to determine the seat pitch and width of equipment from various carriers, which are used to more accurately determine the area occupied by each seat.

Step 6: Adjust for passenger load

Typically, airline flights are not 100 percent full. To more accurately calculate the CO_2 emissions, the emissions are allocated among the average number of passengers for that carrier. Passenger load factor data are gathered from data supplied by the International Civil Aviation Organization (ICAO), an agency of the United Nations. ICAO is an authoritative source of passenger load factor information for U.S. and non-U.S. carriers. Data from calendar year 2006 is used to avoid seasonality issues. These values are updated annually. If a carrier is not in the list, the average load factor of 75.93 percent is used for U.S. carriers and 67.35 percent for non-U.S. carriers.

C.2 Transmission and Distribution Losses

Description

This category includes the emissions associated with the purchased electricity consumed by the T&D system.

C.2.1 Default Methodology (Calculated by GHG Reporting Portal)[72]

Data Sources

The GHG Reporting Portal will utilize this default calculation methodology. It will automatically draw from the existing FEMP energy reporting data reported under scope 2 and subsequently apply a national loss factor to calculate T&D energy losses (Table C-3). The GHG Reporting Portal will calculate the lost quantity of energy and estimate its resultant GHG emissions using the appropriate emission factors.

Table C-3: T&D Losses Default Data Sources

Data Element	Preferred Source
Total electricity purchases [MWh]	• FEMP Energy Report Records
National average T&D loss factor [%]	• Electricity: 6.18 %

[72] This methodology is based on Rothschild (Pechan) and Diem (EPA), Guidance on the Use of eGRID Output Emission Rates, April 2009, p. 2. See www.epa.gov/ttn/chief/conference/ei18/session5/rothschild.pdf.

Calculation Steps

Electricity

Electricity T&D losses are calculated using Equation C-1. These calculations account for the eGRID output emission rate factors adjustments that exclude T&D losses. The following steps detail the calculations methods utilized by the GHG Reporting Portal:

1. Import the electricity purchased data by eGRID subregion from FEMP energy reporting
2. Determine the electricity T&D loss adjustment factor
3. Calculate the T&D loss quantity and the associated GHG emissions
4. Determine total annual emissions in MT CO_2e

Step 1: Import the electricity purchased data by eGRID region from FEMP energy reporting

All agencies are required to report their total electricity consumption through FEMP energy reporting by eGRID subregion. These quantities are already input to the GHG Reporting Portal to account for the electricity usage under the scope 2. The GHG Reporting Portal automatically imports these data for calculation of the T&D losses.

Step 2: Determine electricity T&D loss adjustment factor

This default methodology currently uses a national average T&D loss of 0.618 (or 6.18 percent) and Equation C-1 to determine the electricity loss adjustment factor.

Equation C-1: Distribution Loss Adjustment Factor Calculation

Distribution Loss Adjustment Factor = T ÷ (1-T)

Where:

T = T&D loss factor, 0.618 (or 6.18 percent) national average.

Step 3: Calculate the T&D loss quantity and the associated GHG emissions

The GHG Reporting Portal applies the national average default value of 0.0618 for the T&D loss to determine the total quantity of electricity lost by eGRID subregion. It subsequently applies the appropriate eGRID output emission rate factors as provided in Table D-8.

Scope 2 purchased electricity output emission rate factors are provided by the EPA eGRID. The eGRID database divides the national electricity grid into 26 subregions with unique output emission rate factors based on the regional electricity generation mix as shown in Table D-8. Agencies can map a facility's zip code to the corresponding eGRID subregion using the EPA Power Profiler website.

Equation C-2: Calculation of Electricity T&D Losses and Emissions

CO_2 emissions [MT] = Electricity purchased [MWh] ● T&D adjustment factor ● CO_2 emission factor [kg/MWh] ● 0.001 [MT/kg]
N_2O emissions [MT] = Electricity purchased [MWh] ● T&D adjustment factor ● N_2O emission factor [kg/MWh] ● 0.001 [MT/kg]
CH_4 emissions [MT] = Electricity purchased [MWh] ● T&D adjustment factor ● CH_4 emission factor [kg/MWh] ● 0.001 [MT/kg]

Source: DOE 1605(b), Technical Guidance

Step 4: Determine total annual emissions in MT CO_2e

Using the GWP values found in Table D-13 to convert them to units of CO_2e, then sum the emissions from all three gases.

Equation C-3: Conversion of GHG MT to CO_2e Emissions

CO_2e Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

Example C-1: Determine Transmission and Loss Emissions for Purchased Electricity

A Federal energy manager for a VA hospital in southern Texas is tasked to determine the T&D loss from electricity purchased during FY 2008. To determine the emissions associated with that T&D loss, the federal manager should do the following:

Step 1: Import the electricity purchased data by eGRID region from FEMP energy reporting

The FEMP energy reporting data indicate that total purchased electricity for the hospital facility is 20,000 MWh.

Step 2: Determine electricity T&D loss adjustment factor

Equation C-1 is then used to calculate the loss adjustment factor.

Equation C-1: Distribution Loss Adjustment Factor Calculation
0.0618 ÷ (1 - 0.0618) = 0.0618 ÷ 0.9382 = 0.0659

Step 3: Calculate the T&D loss quantity and the associated GHG emissions

Because the facility is in southern Texas, it is within the ERCT eGRID subregion, so the ERCT eGRID output emission rate factor must be used for the calculation.

Equation C-2: Calculate Electricity T&D Losses and Emissions

CO_2 emissions [MT] = Electricity purchased [MWh] ● CO_2 emission factor [kg/MWh] ● T&D adjustment factor ● 0.001 [MT/kg]
= 20,000 [MWh] ● 0.0659 ● 600.71 [kg/MWh] ● 0.001 [MT/kg]
= 791.74 [MT] CO_2

N_2O emissions [MT] = Electricity purchased [MWh] ● N_2O emission factor [kg/MWh] ● T&D adjustment

	factor ● 0.001 [MT/kg] = 20,000 [MWh] ● 0.0659 ● 6.85 [kg/MWh] ● 0.001 [MT/kg] = 9.03 [MT] N_2O
CH_4 emissions [MT]	= Electricity purchased [MWh] ● CH_4 emission factor [kg/MWh] ● T&D adjustment factor ● 0.001 [MT/kg] = 20,000 [MWh] ● 0.0659 ● 8.46 [kg/MWh] ● 0.001 [MT/kg] = 11.15 [MT] CH_4
Step 4: Convert CH_4 and N_2O to CO_2e Using the appropriate GWP, convert all GHG gases to CO_2e, then sum to determine the total emissions in CO_2e.	
Equation C-3: Convert GHG MT to CO_2e Emissions	
CO_2e Emissions [MT CO_2e]	= MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP) = 791.74 [MT CO_2] + (11.15 [MT CH_4] ● 21) + (9.03 [MT N_2O] ● 310) = 791.74 [MT CO_2] + 234.15 [MT CO_2e] + 2799.3 [MT CO_2e] **= 3825.19 [MT CO_2e]**
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**	

C.3 Contracted Municipal Solid Waste Disposal

Description

Contracted disposal of agency waste refers to the off-site disposal of municipal solid waste performed by an independent entity. Appendix A provides guidance on inventorying emissions from agency-controlled municipal solid waste disposal. However, the mass balance methodology[73] for contracted landfill disposal of municipal solid waste generation of CH_4 and biogenic CO_2 differs from the LandGEM based approach used in scope 1. This difference is primarily due to the lack of control over the municipal solid waste once disposed and the temporal data management complexities with applying a multiyear first-order decomposition model. Despite the CH_4 and biogenic CO_2 generation difference, the methodology used is otherwise identical to that outlined in scope 1.

C.3.1 Default Methodology (Calculated by GHG Reporting Portal)

Data Sources

Table C-4 shows the data elements and their sources.

[73] This method is based upon the estimate approach used in the EPA Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2007, p. A-304, and EPA, Climate Leaders, Landfill Offset Methodology. See www.epa.gov/climatechange/emissions/downloads09/Annex3.pdf and www.epa.gov/stateply/documents/resources/draft_landfill_offset_protocol.pdf.

Table C-4: Contracted Solid Waste Disposal Default Data Sources

Data Element		Preferred Source
Mass of solid waste disposed [short ton]		Reporting to OFEE under EO 13514, Sec. 2(e)
Mass of biogenic CO_2 and CH_4 [MT (Mg)]		Calculated by GHG Reporting Portal using EPA
Does the landfill have a LFG collection system?		GHG Reporting Portal assumes 50% include LFG collection system
Methane concentration rate, k		Default provided by GHG Reporting Portal
Potential methane generation capacity, Lo		Default provided by GHG Reporting Portal
NMOC concentration [ppmv]		Default provided by GHG Reporting Portal
Methane content of LFG [% by volume]		Default provided by GHG Reporting Portal
If LFG collection system	Efficiency of LFG collection system	Default provided by GHG Reporting Portal
	Oxidation factor	Default provided by GHG Reporting Portal

*1 MT = 1 Mg (megagram)

Calculation Steps

Step 1: Use EPA's municipal solid waste mass balance model to calculate the CH_4 and CO_2 generation and input into GHG Reporting Portal

The agency inputs the annual deposition of solid waste into the GHG Reporting Portal. Using this quantitative input, the GHG Reporting Portal uses the EPA's mass balance model and its national default values to calculate an estimate of quantity of municipal solid waste's anthropogenic CH_4 and biogenic CO_2 emissions over time. The derived calculations are outlined in Equation C-4 and Equation C-5, respectively.

Equation C-4: CH_4 Generation per Short Ton of Municipal Solid Waste

CH_4 Generation [MT] = MSW_{mass} ● 0.90718 ● DOC ● DOC_f ● MCF ● F ● 16/12

Where:

CH_{4gen} = CH_4 generated by landfill [MT]

MSW_{mass} = Municipal solid waste disposed of in landfill [short ton]

0.90718 = Conversion from short ton to MT [MT/short ton]

DOC = Degradable organic carbon [MT C/MT waste], default value of 0.203

DOC_f = Degradable organic carbon digestible under the anaerobic conditions in the landfill [%], default value of 50%

MCF = Methane correction factor/uncontrolled release of CO_2 [%], default value of 1%

F = Fraction of CH_4 by volume in generated landfill gas, default value of 50%

16/12 = Molecular weight ratio CH_4/C

Source: EPA Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007, p. A-304. See: www.epa.gov/climatechange/emissions/downloads09/Annex3.pdf

Equation C-5: Biogenic CO_2 Generation per Short Ton Municipal Solid Waste

CO_2 Generation [MT] = MSW_{mass} ● 0.90718 ● DOC ● DOC_f ● MCF ● F ● 16/12

Where:

CO_{2gen} = CO_2 generated by landfill [MT]

MSW_{mass} = Municipal solid waste disposed of in landfill [short ton]

0.90718 = Conversion from short ton to MT [MT/short ton]

DOC = Degradable organic carbon [MT C/MT waste], default value of 0.203

DOC_f = Degradable organic carbon digestible under the anaerobic conditions in the landfill [%], default value of 50%

MCF = Methane correction factor/uncontrolled release of CO_2 [%], default value of 1%

F = Fraction of CH_4 by volume in generated landfill gas, default value of 50%

44/12 = Molecular weight ratio CO_2/C

Source: EPA Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2007, p. A-304. See www.epa.gov/climatechange/emissions/downloads09/Annex3.pdf

Step 2: Calculate emissions from landfills and solid waste facilities

The GHG Reporting Portal automatically calculates the quantities of CH_4 and biogenic CO_2 in metric tons. The portal applies the scope 1 methodology outlined in Appendix A.7.1 using the national default values to calculate the emissions from uncontrolled release, fugitive CH_4 losses, flare combustion, and venting.

C.3.2 Advanced Methodology (User Calculated)[74]

Data Sources

Agencies can utilize the same variable listed above for the default methodology but substitute site-specific or facility-level data available from the third-party contractor.

Calculation Steps

The advanced calculation methods for the contracted solid waste calculations are identical to those of the default, except for use of the site-specific data available from the third-party contractor, which may be available from the provider as part of its regulatory compliance for EPA MRR.

C.4 Federal Employee Business Ground Travel: Rail, Rentals, Buses

Business ground travel refers to official business travel by Federal employees aboard third-party-owned or -operated ground vehicles.[75] It does not include daily commutes to, from, or within an

[74] This methodology is derived from the Climate Leaders Optional Emissions from Commuting, Business Travel, and Product Transport methodology. See www.epa.gov/stateply/documents/resources/commute_travel_product.pdf.

employee's official station, only official business travel as defined in the Federal Travel Regulations (FTR). Scope 3 emissions from business travel include those from the combustion of fuels (such as the fuel consumed by a vehicle), but not the life-cycle emissions associated with fuel production or manufacturing capital equipment and infrastructure (such as the emissions associated with vehicle manufacturing). Employee business ground travel is optional for GHG reporting.

Business ground travel includes the following:

- Passenger vehicle business travel: personal vehicles, rental vehicles, and taxi cabs
- Rail business travel: transit rail (such as subway, tram), commuter rail, and intercity rail (such as Amtrak)
- Bus business travel: diesel-fired buses and, to a lesser extent, other fuels such as compressed natural gas (CNG)

Reporting emissions from business ground travel is encouraged for FY 2010 reporting and required for FY 2011 reporting.

C.4.1 Default Methodology (Calculated by GHG Reporting Portal)[76]

Data Sources

The default calculation methodology is derived from average travel statistics provided by GSA. The current method is intended to give agencies an initial estimate of ground travel emissions based on the primary source (rental vehicles) and national averages (Table C-5). A more robust and accurate default method is under development for FY11 in concurrence with GSA.

Table C-5: Ground-Travel Default Data Sources

Data Element	Preferred Source
Number of rentals	GSA Travel MIS or Agency's Travel Agent

Calculation Steps

The GHG Reporting Portal uses the following steps to calculate emissions:

1. Report the number of agency-wide rentals
2. Calculate miles traveled using a given conversion factor
3. Determine total annual GHG emissions

[75] The current methodologies presented do not include provisions for business travel over water (ferries, water taxis, etc.). However, agencies may choose to optionally report such emissions should sufficient data and methods become available at the time of reporting.
[76] This methodology is based on correspondence with the GSA Office of Travel and Transportation.

Step 1: Report the number of agency-wide rentals

Agencies should work with their GSA Travel MIS Rental Car report or their travel agent to determine how many times agency employees rented vehicles during the fiscal year. The GHG Reporting Portal only requires the agencies to report the number of rentals, not the distance traveled per rental or number of days the vehicle was rented.

Step 2: Calculate miles traveled using a given conversion factor

The GHG Reporting Portal will multiply the number of car rentals by an average factor of 419 miles traveled per rental (an average duration of 5.1 days).[77]

Step 3: Determine total annual GHG emissions

The GHG Reporting Portal uses Equation C-6 and the distance-traveled emission factors in Table D-4 and Table D-5 to calculate the CO_2, N_2O, and CH_4 emissions for the applicable car rentals. It multiplies each GHG quantity by the appropriate GWP value from Table D-13 and then calculates the total emissions in CO_2e.

C.4.2 Advanced Methodology (User Calculated)

Data Sources

Agencies can use this advanced distance-traveled methodology to calculate emissions from employee business ground travel.[78] Agencies can use distance travel activity data captured by mode of ground transportation to calculate their emissions (Table C-6). If agencies are unable to obtain adequate distance-traveled data, they may extrapolate total ground-travel emissions from a representative sample of distance-based activity data.

Table C-6: Ground-Travel Required Data Sources

Data Element	Preferred Sources
Distance traveled (miles) by mode of ground transport (rental car, POV, bus, train) [mi]	• Rental Vehicles: GSA Travel MIS or Agency's Travel Agent • Personal Vehicles, Rail, Bus: Travel reimbursement forms • Representative sample of distance based data
Emission factor [g/mi]	• Table D-11 and Table D-12

Calculation Steps

[77] This factor is provided by the GSA Office of Travel and Transportation, based on correspondence with rental agencies. The factor is a national average of all government rentals with three rental companies. These agencies constitute about 40 percent of total Federal rentals.
[78] This methodology is derived from the Climate Leaders Optional Emissions from Commuting, Business Travel, and Product Transport methodology. See www.epa.gov/stateply/documents/resources/commute_travel_product.pdf.

This advanced calculation methodology is derived from the EPA Climate Leaders guidance for *Optional Emissions from Commuting, Business Travel and Product Transport*. Calculation steps include the following:

1. Determine distance traveled for each mode of transportation
2. Calculate emissions for each mode of transportation
3. Determine the total annual GHG emissions
4. Convert emissions to CO_2e

Step 1: Determine distance traveled for each mode of transportation

Agencies should gather distance-traveled data on all business ground travel. The distance-traveled data for each mode of transportation can typically be found in travel agent records or travel reimbursement forms. If agencies are unable to obtain complete ground travel data, they may extrapolate from a representative sample of employees to represent the total business travel of all employees but must report their extrapolation methodology.

Step 2: Calculate emissions for each mode of transportation

Agencies should use Equation C-6 and the distance-traveled emission factors found in Table D-11 and Table D-12 to calculate the CO_2, N_2O, and CH_4 emissions for each mode of travel. It is important to note that the emission factors used are determined by how they are allocated. For instance, a single occupancy rental passenger car or a POV SUV would each have separate emission factors because of the difference in vehicle use. However, agencies could choose to modify these emission factors for multiple occupant trips should sufficiently granular data become available. More detailed information on multiple occupant allocations is provided in the commuter methodologies below should agency data at this resolution become available.

Equation C-6: Emissions by Transportation Mode

CO_2 emissions[kg] = Distance traveled for a given mode [miles] ● CO_2 emission factor for each mode [kg/mi]
N_2O emissions [kg] = Distance traveled for a given mode [miles] ● N_2O emission factor for each mode [g/mi] ● 0.001 [kg/g]
CH_4 emissions[kg] = Distance traveled for a given mode [miles] ● CH_4 emission factor for each mode [g/mi] ● 0.001 [kg/g]
Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Step 3: Determine the total annual GHG emissions in metric tons

To determine the total CO_2, N_2O, and CH_4 emissions, sum the emissions of each gas for all ground transportation modes and convert them to metric tons.

Equation C-7: Total Emissions Calculations

Total CO_2 emission from ground travel [MT] = (CO_2 from node 1 [kg] + CO_2 from node 2 [kg] + CO_2 from node 3 [kg] …) ● 0.001MT/kg
Total N_2O emission from ground travel [MT] = (N_2O from node 1 [kg] + N_2O from node 2 [kg] + N_2O from node 3 [kg] …) ● 0.001MT/kg
Total CH_4 emission from ground travel [MT] = (CH_4 from node 1 [kg] + CH_4 from node 2 [kg] + CH_4 from node 3 [kg] …) ● 0.001MT/kg
Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Step 4: Convert emissions to CO_2e

Multiple the N_2O and CH_4 emissions by their respective GWP to determine the CO_2e for business ground travel.

Equation C-8: Ground Travel MT CO_2e Emissions

CO_2e Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

C.5 Federal Employee Commuting

Description

Employee commuting includes the travel of employees between their homes and primary worksites or between their homes and alternate worksites.

Reporting emissions from employee commuting travel is encouraged for FY 2010 reporting and required for FY 2011 reporting.

C.5.1 Default Methodology (Calculated by GHG Reporting Portal)

Data Sources

Agencies should, if at all possible, use voluntary questionnaires[79] to obtain information on average employee commuting habits.[80] At a minimum, agencies should seek information on the following:

- Frequency of commute
- Average one-way distance traveled by employee per day

[79] Agencies should be aware that there are privacy rights to be considered when developing and administering any voluntary survey.
[80] This methodology is derived from Climate Leaders, Optional Emissions from Commuting, Business Travel, and Product Transport methodology. See www.epa.gov/stateply/documents/resources/commute_travel_product.pdf.

- Modes of transport used by employees (personal vehicle, train, bus, etc.)

Agencies should collect employee commuting questionnaire data from as many employees as possible. However, some extrapolation will likely be necessary. Agencies may extrapolate using a representative sample of employees to represent the total commuting patterns of all employees.

If agencies are unable to send questionnaires to their employees, they should look to on-site data sources such as parking permits or payroll records to gather information on distance traveled, mode of transport, and frequency of commute (Table C-7). If no on-site data are available, agencies should use regional or national databases to estimate the necessary data sources, such as the U.S. Census Bureau at: www.census.gov/acs/www/index.html.

Table C-7: Commuter Travel Data Sources

Data Element	Preferred Source	Alternate Source
Number of passengers (by mode)	• Commuter questionnaire	• N/A
Mode	• Commuter questionnaire	• Public transit records • Regional/national transportation surveys
Number of trips (by mode)	• Commuter questionnaire	• Regional/national transportation surveys (such as U.S. Census Bureau)
Distance of trip (by mode) [mi]	• Commuter questionnaire	• Commuter address (payroll records, personnel records, parking permits) • Regional/national transportation surveys (such as U.S. Census Bureau)
Emission factors [g/passenger-mile]	• Tables D-11 and D-12	• N/A

Calculation Steps

1. Collect commuter data by frequency, distance, and mode travel activity data
2. Segregate commuter data by single occupant or multiple passenger categories and compute annual travel averages
3. Calculate emissions of single occupant and multiple passenger commuters
4. Sum single occupant and multiple passenger travel emissions and convert them to metric tons
5. Convert them to CO_2e and determine total emissions

Step 1: Collect commuter data by frequency, distance, and mode travel activity data

Agencies should collect activity data for commuters using a commuter questionnaire, if possible. Agencies should collect employee commuting data from a statistically appropriate number of respondents and extrapolate from a representative sample of employees to estimate commuting patterns of all employees.

If agencies are unable to use questionnaires to obtain information from their employees, internal data sources, such as parking permits, bus passes, or payroll records may be used to estimate distance traveled, mode of transport, and frequency of commute. If internal data are not available, agencies should default to the regional or national averages for commuting modes and distances from sources, such as the U.S. Census Bureau. To account for emission-saving strategies that focus on modifying employee commuting behavior (such as encouraging use of carpooling or public transit), agencies will need to use commuter survey data specific to the agency population.

Step 2: Segregate commuters by solo passengers or multiple passenger occupants and compute annual travel averages

Agencies should categorize the available data by those who commute to work alone and those who commute in multiple occupant vehicles (such as carpools, bus, or subway). For the respective groups, agencies determine the average distance traveled and the average frequency of trips per year, and then enter these data into the GHG Reporting Portal.

Step 3: Calculate emissions of single occupant and multiple occupant commuters

The GHG Reporting Portal will use Equation C-9 to calculate GHG emission for single occupant vehicle travel and Equation C-10 should be used to calculate GHG emission for each mode of multi-occupant travel. (See Table D-12 for emission factors for commuting.) Note that the listed emission factors assume that commuting vehicles have two passengers per carpool and four passengers per van-pool. See Example C-2.

Equation C-9: Emissions from Single Occupant Vehicle Travel

CO_2 emissions [kg] = Number of trips per year ● number of single occupant travelers at the agency ● average mileage per trip [mi] ● emission factor [kg/mi]
N_2O emissions [kg] = Number of trips per year ● number of single occupant travelers at the agency ● average mileage per trip [mi] ● emission factor [g/mi] ● 0.001 [kg/g]
CH_4 emissions [kg] = Number of trips per year ● number of single occupant travelers at the agency ● average mileage per trip [mi] ● emission factor [g/mi] ● 0.001 [kg/g]
Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport

Equation C-10: Emissions by Transportation Mode for Multiple Occupant Travel

CO_2 emissions [kg] = Number of trips per year ● number of agency employees traveling by mode ● average mileage per trip [mi] ● (emission factor for each mode [kg/passenger-mile])
N_2O emissions [kg] = Number of trips per year ● number of agency employees traveling by mode ● average mileage per trip [mi] ● (emission factor for each mode [g/passenger-mile]) ● 0.001 [kg/g]
CH_4 emissions [kg] =

Number of trips per year ● number of agency employees traveling by mode ● average mileage per trip [mi] ● (emission factor for each mode [g/passenger-mile]) ● 0.001 [kg/g]
Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport The individual equations for each gas in Equation C-10 should be repeated for each transportation mode

Step 4: Sum single occupant and multiple occupant travel emissions and convert them to MT

Use Equation C-11 to add the respective CO_2, N_2O, and CH_4 emissions from single occupant vehicle travel and each mode of the multiple occupant vehicle travel.

Equation C-11: Total Emissions Calculations

Total CO_2 emission from commuter travel [MT] = (CO_2 from mode 1 [kg] + CO_2 from mode 2 [kg] + CO_2 from mode 3 [kg] …) ● 0.001MT/kg
Total N_2O emission from commuter travel [MT] = (N_2O from mode 1 [kg] + N_2O from mode 2 [kg] + N_2O from mode 3 [kg] …) ● 0.001MT/kg
Total CH_4 emission from commuter travel [MT] = (CH_4 from mode 1 [kg] + CH_4 from mode 2 [kg] + CH_4 from mode 3 [kg] …) ● 0.001MT/kg
Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport.

Step 5: Convert to CO_2e and determine total emissions

Use Equation C-12 to multiple the N_2O and CH_4 emissions by their respective GWP (See Table D-13) to determine the total CO_2e emissions.

Equation C-12: Commuter Travel MT CO_2e Emissions

CO_2e Emissions [MT CO_2e] = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP)

Example C-2: Estimate Employee Emissions from Commuting

The Department of Commerce is attempting to estimate total commuter emissions for a notional facility in Chicago to determine the emissions associated with their employees' commutes.

Step 1: Collect commuter data by frequency, distance, and mode travel activity data

The agency creates an online questionnaire and, after tabulating the data, determines that of the 1,000 employees of the facility, 25 percent drive in a single occupant vehicle, and 75 percent commute in multiple occupant vehicles.

Step 2: Segregate commuters by solo passengers or multiple passenger occupants and compute annual travel averages

The single occupant vehicle commuters average 30 miles per daily roundtrip in passenger cars. The multiple-occupant vehicle commuters are broken down in the following way: 40 percent commute the Chicago Transit Authority's transit train system, averaging 16 miles per daily round trip. Thirty percent rely on bus travel for 20

miles per daily round trip. The remaining 5 percent of employees carpool, with an average daily roundtrip of 40 miles (and a passenger load of two passengers per vehicle). All commuters average 225 daily roundtrip commutes per year.

Mode of Transportation [type]	Number of employees	Number of trips per year	Average daily mileage [miles]
Single occupant vehicle	250	225	30
Transit Rail	400	225	16
Bus	300	225	20
Carpool	50	225	40

Step 3: Calculate emissions of single occupant and multiple occupant commuters
Equation C-9 allows for the calculation to determine single occupant emissions. The emission factors for passenger cars are found in Table D-11 and D-12.

Equation C-9: Emission from Single Occupant Vehicle Travel

CO_2 emissions [kg] = Number of trips per year ● number of single occupant travelers at the agency ● average mileage per trip [miles] ● emission factor [kg/mile]
= 225 ● 250 ● 30 [mi] ● 0.364 [kg/mi]
= 614250 [kg CO_2]

CH_4 emissions [kg] = Number of trips per year ● number of single occupant travelers at the agency ● average mileage per trip [mi] ● emission factor [kg/mi]
= 225 ● 250 ● 30 [mi] ● 0.031 [g/passenger-mile]) ● 0.001 [kg/g]
= 52.31 [kg CH_4]

N_2O emissions [kg] = Number of trips per year ● number of single occupant travelers at the agency ● average mileage per trip [mi] ● emission factor [kg/mile]
= 225 ● 250 ● 30 [mi] ● 0.032 [g/passenger-mile]) ● 0.001 [kg/g]
= 54.00 [kg N_2O]

Equation C-10 allows for the calculation to determine multiple occupant emissions. Emission factors are pulled from Table D-12. The following equations are repeated for each transportation mode.

Equation C-10: Emissions by Transportation Mode for Multiple Occupant Travel

Transit Rail

CO_2 emissions [kg] = Number of trips per year ● number of agency employees traveling by transit rail ● average mileage per trip [mi] ● emission factor for transit rail [kg/passenger-mile]
= 225 ● 400 ● 16 [mi] ● 0.163 [kg/passenger-mile]
= 234720 [kg CO_2]

N_2O emissions [kg] = Number of trips per year ● number of agency employees traveling by transit rail ● average mileage per trip [mi] ● emission factor for transit rail [g/passenger-mile]) ● 0.001 [kg/g]
= 225 ● 400 ● 16 [mi] ● 0.002 [g/passenger-mile]) ● 0.001 [kg/g]
= 2.88 [kg N_2O]

CH_4 emissions [kg] = Number of trips per year ● number of agency employees traveling by transit rail ●

average mileage per trip [mi] ● emission factor for transit rail [g/passenger-mile]) ● 0.001 [kg/g]
= 225 ● 400 ● 16 [mi] ● 0.004 [g/passenger-mile]) ● 0.001 [kg/g]
= 5.76 [kg CH_4]

Bus

CO_2 emissions [kg] = Number of trips per year ● number of agency employees traveling by bus ● average mileage per trip [mi] ● emission factor for bus [kg/passenger-mile]
= 225 ● 300 ● 20 [mi] ● 0.107 [kg/passenger-mile]
= 144450 [kg CO_2]

N_2O emissions [kg] = Number of trips per year ● number of agency employees traveling by bus ● average mileage per trip [mi] ● emission factor for bus [g/passenger-mile]) ● 0.001 [kg/g]
= 225 ● 300 ● 20 [mi] ● 0.0005 [g/passenger-mile]) ● 0.001 [kg/g]
= 0.675 [kg N_2O]

CH_4 emissions [kg] = Number of trips per year ● number of agency employees traveling by bus ● average mileage per trip [mi] ● emission factor for bus [g/passenger-mile]) ● 0.001 [kg/g]
= 225 ● 300 ● 20 [mi] ● 0.0006 [g/passenger-mile]) ● 0.001 [kg/g]
= 0.81 [kg CH_4]

Carpool

CO_2 emissions [kg] = Number of trips per year ● number of agency employees traveling by carpool ● average mileage per trip [miles] ● emission factor for carpool [kg/passenger-mile]
= 225 ● 50 ● 40 [miles] ● 0.182 [kg/passenger-mile]
= 491400 [kg CO_2]

N_2O emissions [kg] = Number of trips per year ● number of agency employees traveling by mode ● average mileage per trip [miles] ● emission factor for each mode [g/passenger-mile]) ● 0.001 [kg/g]
= 225 ● 50 ● 40 [miles] ● 0.016 [g/passenger-mile]) ● 0.001 [kg/g]
= 43.2 [kg N_2O]

CH_4 emissions [kg] = Number of trips per year ● number of agency employees traveling by mode ● average mileage per trip [miles] ● emission factor for each mode [g/passenger-mile]) ● 0.001 [kg/g]
= 225 ● 50 ● 40 [miles] ● 0.016 [g/passenger-mile]) ● 0.001 [kg/g]
= 41.85 [kg CH_4]

Step 4: Sum single occupant and multiple occupant travel emissions and convert them to metric tons

Use Equation C-11 to add the respective CO_2, N_2O, and CH_4 emissions from all employees.

Equation C-11: Total Emissions Calculations

Total CO_2 emission from commuter travel [MT]
= (CO_2 from mode 1 [kg] + CO_2 from mode 2 [kg] + CO_2 from mode 3 [kg] …) ● 0.001 [MT/kg]
= (CO_2 single occupant [kg] + CO_2 transit rail [kg] + CO_2 bus [kg] + CO_2 carpool [kg]) ● 0.001 [MT/kg]
= (614250 [kg] + 234720 [kg] + 144450 [kg] + 491400 [kg]) ● 0.001 [MT/kg]
= 1484820 [kg] ● 0.001 [MT/kg]

= 1484.82 [MT CO_2]
Total N_2O emission from commuter travel [MT] = = (N_2O from mode 1 [kg] + N_2O from mode 2 [kg] + N_2O from mode 3 [kg] …) ● 0.001 [MT/kg] = (N_2O single occupant [kg] + N_2O transit rail [kg] + N_2O bus [kg] + N_2O carpool [kg]) ● 0.001 [MT/kg] = (54.00 [kg] + 2.88 [kg] + 0.675 [kg] + 43.2 [kg]) ● 0.001 [MT/kg] = 100.755 [kg] ● 0.001 [MT/kg] = 0.101 [MT N_2O]
Total CH_4 emission from commuter travel [MT] = = (CH_4 from mode 1 [kg] + CH_4 from mode 2 [kg] + CH_4 from mode 3 [kg] …) ● 0.001 [MT/kg] = (CH_4 single occupant [kg] + CH_4 transit rail [kg] + CH_4 bus [kg] + CH_4 carpool [kg]) ● 0.001 [MT/kg] = (52.31 [kg] + 5.76 [kg] + 0.81 [kg] + 41.85 [kg]) ● 0.001 [MT/kg] = 100.73 [kg] ● 0.001 [MT/kg] = 0.101 [MT CH_4]
Step 5: Convert to CO_2e and determine total emissions Use Equation C-12 to multiply the total N_2O and CH_4 emissions by their respective GWP (see Table D-13) to determine the total CO_2e emissions.
Equation C-12: Commuter Travel MT CO_2e Emissions **Total CO_2e Emissions [MT CO_2e]** = MT CO_2 + (MT CH_4 ● CH_4 GWP) + (MT N_2O ● N_2O GWP) = 1484.82 [MT CO_2] + (0.101 [MT CH_4] ● 21) + (0.101 [MT N_2O] ● 310) = 1484.82 [MT CO_2]+ 2.12 [MT CO_2e] + 31.31 [MT CO_2e] **= 1518.25 [MT CO_2e]**
Note: Example has been provided for demonstration purposes only and has rounding imposed throughout each of the calculation steps above. As such results from this example may differ slightly from results generated using the GHG Portal.**

C.6 Contracted Wastewater Treatment

Description

Appendix A.6 provides guidance on inventorying emissions from agency-controlled wastewater treatment. Although this calculation methodology is identical, the data sources for contracted wastewater treatment differ because of the inherent scope boundary issues between 1 and 3. As such, contracted wastewater treatment population inputs only include Federal employees.

C.6.1 Default Methodology (Calculated by GHG Reporting Portal)

Data Sources[81]

Table C-8 shows the data elements and their preferred and alternate sources.

[81] This methodology is derived from The Climate Registry's *Local Government Operations Protocol*. See www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/.

Table C-8: Contracted Wastewater Treatment Default Data Sources

Data Element	Preferred Source	Alternate Source
Employees served	• Agency records	• N/A
Type of WWTP	• Wastewater treatment contractor	• Default provided

Calculation Steps

Agencies enter their respective employee served data into the GHG Reporting Portal. It utilizes national average composition of WWTP treatment to estimate the employees being served by the respective wastewater treatment system type. These numbers are then applied using the default wastewater treatment methodology outlined in Appendix A.6.1.

C.6.2 Advanced Methodology (User Calculated)

Data Sources

Table C-9 shows the data elements and their sources.

Table C-9: Contracted Wastewater Treatment Data Sources

Data Element	Preferred Source
Population served	• Agency records
Wastewater treatment processes used	• Wastewater treatment contractor
Digester gas [cu ft/day]	• Wastewater treatment contractor
Fraction of CH_4 in biogas	• Wastewater treatment contractor
BOD_5 load [kg BOD_5/day]	• Wastewater treatment contractor
Fraction of overall BOD_5 removal performance	• Wastewater treatment contractor
N load	• Wastewater treatment contractor

Calculation Steps

See Appendix A.6 for advanced methodology wastewater calculations.

Appendix D—Emission and Conversion Factors

Table D-1 summarizes the emission and conversion factors found in this appendix.

Table D-1: Summary of Emission Factors and Conversion Factors with Sources

Factor Type	Data Source Reference	Reference Section	Appendix D Table #	Applicable Scope
CO_2 Emission Factors and HHVs for Various Types of Fuel	EPA, Mandatory Greenhouse Gas Reporting Rule, *Federal Register, Friday, October 30, 2009* www.epa.gov/climatechange/emissions/ghgrulemaking.html	Table C-1 to Subpart C of Part 98	D-2	Scope 1
CH_4 and N_2O Emission Factors for Various Types of Fuel		Table C-2 to Subpart C of Part 98	D-3	Scope 1, Other reporting
N_2O and CH_4 Emission Factors for Highway Vehicles	EPA, EPA Climate Leaders, Mobile Sources Guidance, www.epa.gov/stateply/documents/resources/commute_travel_product.pdf.	Table A-1	D-4	Scope 1 & 3
N_2O and CH_4 Emission Factors for Alternative Fuel Vehicles		Table A-7	D-5	Scope 1 & 3
N_2O and CH_4 Emission Factors for Non-Highway Vehicles		Table A-6	D-6	Scope 1
Default F-Gas Emission Factors for Refrigeration/ Air Conditioning Equipment	EPA Climate Leaders, Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Equipment, www.epa.gov/stateply/documents/resources/mfgrfg.pdf	Table 2	D-7	Scope 1
eGRID Subregion Output Emission Rate Factors	eGRID2007 Version 1.1 Year 2005 Summary Tables, p.6, output emission rates column,[82] www.epa.gov/cleanenergy/documents/egridzips/eGRID2007V1_1_year05_SummaryTables.pdf	eGRID2007 Version 1.1 Year 2005 Summary Tables	D-8	Scope 2 & 3
Steam/Hot Water Emission Factor	DOE 1605(b): Technical Guidance: www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf.	Part F: Indirect Emissions	D-9	Scope 2 & 3

[82] The GHG Reporting Portal will include the latest eGRID output emission rate factors.

Factor Type	Data Source Reference	Reference Section	Appendix D Table #	Applicable Scope
Chilled Water Emission Factors	DOE 1605(b), Technical Guidance: www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf.	Part F: Indirect Emissions and Appendix N	D-9	Scope 2 & 3
Ground Business and Commuter Personal Vehicle Emission Factors	EPA, Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport, www.epa.gov/stateply/documents/resources/commute_travel_product.pdf		D-10	Scope 3
Commuter & Mass Transit Emission Factors			D-11	Scope 3
Global Warming Potentials	EPA, Mandatory Greenhouse Gas Reporting Rule, *Federal Register, Friday, October 30, 2009* www.epa.gov/climatechange/emissions/ghgrulemaking.html	Table A-1 to Subpart A of Part 98	D-12	All
General Conversion Factors		Table A-2 to Subpart A of Part 98	D-13	All
Gasoline Gallon Equivalent Conversion Factors	DOE and GSA, Federal Automotive Statistical Tool, https://fastweb.inel.gov/		D-14	Scope 1

The following section describes emission factors by scope and emission category, GWP, and conversion factors in more detail.

Scope 1 Combustion Emission Factors

For scope 1 emissions, the methodologies use emission factors from the EPA's Mandatory Greenhouse Gas Reporting Rule (MRR) and Climate Leaders guidance Table D-2 and Table D-3 list key combustion factors.

Table D-2: Default CO2 Emission Factors and Higher Heating Values[83] for Various Types of Fuel

Fuel Type	Default HHV	Default CO_2 Emission Factor
Coal and coke	**MMBtu/short ton**	**Kg CO_2/MMBtu**
Anthracite	25.09	103.54
Bituminous	24.93	93.40
Subbituminous	17.25	97.02
Lignite	14.21	96.36
Coke	24.80	102.04
Mixed (commercial sector)	21.39	95.26
Mixed (industrial coking)	26.28	93.65
Mixed (industrial sector)	22.35	93.91
Mixed (electric power sector)	19.73	94.38
Natural Gas	**MMBtu/scf**	**Kg CO_2/MMBtu**
Pipeline (weighted U.S. average)	1.028×10^{-3}	53.02
Petroleum Products	**MMBtu/gallon**	**Kg CO_2/MMBtu**
Distillate Fuel Oil No. 1	0.139	73.25
Distillate Fuel Oil No. 2	0.138	73.96
Distillate Fuel Oil No. 4	0.146	75.04
Distillate Fuel Oil No. 5	0.140	72.93
Distillate Fuel Oil No. 6	0.150	75.10
Still gas	0.143	66.72
Kerosene	0.135	75.20
LPG	0.092	62.98
Propane	0.091	61.46
Propylene	0.091	65.95
Ethane	0.096	62.64
Ethylene	0.100	67.43
Isobutene	0.097	64.91
Isobutylene	0.103	67.74
Butane	0.101	65.15
Butylene	0.103	67.73

[83] Heating value is the amount of energy released when a fuel is burned completely. There is a difference between higher heating values (HHVs) used in the United States and Canada, and lower heating values used in all other countries. HHV is the amount of heat released from the complete combustion of a fuel, including water vapor produced in the process. Lower heating value is the amount of heat released from the complete combustion of a fuel after netting out the heat that is released with the water vapor produced in the process.

Fuel Type	Default HHV	Default CO_2 Emission Factor
Naphtha (<401 degrees F)	0.125	68.02
Natural gasoline	0.110	66.83
Other oil (>401 degrees F)	0.139	76.22
Pentanes plus	0.110	70.02
Petrochemical feedstocks	0.129	70.97
Petroleum coke	0.143	102.41
Special naphtha	0.125	72.34
Unfinished oils	0.139	74.49
Heavy gas oils	0.148	74.92
Lubricants	0.144	74.27
Motor gasoline	0.125	70.22
Aviation gasoline	0.120	69.25
Kerosene-type jet fuel	0.135	72.22
Asphalt and road oil	0.158	75.36
Crude oil	0.138	74.49
Fossil fuel-derived fuels (solid)	**MMBtu/short ton**	**Kg CO_2/MMBtu**
Municipal solid waste	9.95	90.7
Tires	26.87	85.97
Fossil fuel-derived fuels (gaseous)	**MMBtu/scf**	**Kg CO_2/MMBtu**
Blast furnace gas	0.092×10^{-3}	274.32
Coke oven gas	0.599×10^{-3}	46.85
Biomass fuels—solid	**MMBtu/short ton**	**Kg CO_2/MMBtu**
Wood and wood residuals	15.38	93.80
Agricultural byproducts	8.25	118.17
Peat	8.00	111.84
Solid byproducts	25.83	105.51
Biomass fuels—gaseous	**MMBtu/scf**	**Kg CO_2/MMBtu**
Biogas (captured methane)	0.841×10^{-3}	52.07
Biomass fuels—liquid	**MMBtu/gallon**	**Kg CO_2/MMBtu**
Ethanol (100%)	0.084	68.44
Biodiesel (100%)	0.128	73.84
Rendered animal fat	0.125	71.06
Vegetable oil	0.120	81.55

Source: EPA Mandatory Reporting Rule, Federal Register, Friday, October 30, 2009
Table C-1 to Subpart C of Part 98. See www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf.

Table D-3: Default CH_4 and N_2O Emission Factors for Various Types of Fuel

Fuel type	Default CH_4 emission factor (kg CH_4/MMBtu)	Default N_2O emission factor (kg N_2O/MMBtu)
Coal and coke (all fuel types in Table D-1)	1.1×10^{-2}	1.6×10^{-3}
Natural gas	1.0×10^{-3}	1.0×10^{-4}
Petroleum (all fuel types in Table D-1)	3.0×10^{-3}	6.0×10^{-4}
Municipal solid waste	3.2×10^{-2}	4.2×10^{-3}
Tires	3.2×10^{-2}	4.2×10^{-3}
Blast furnace gas	2.2×10^{-5}	1.0×10^{-4}
Coke oven gas	4.8×10^{-4}	1.0×10^{-4}
Biomass fuels—solid (all fuel types in Table D-1)	3.2×10^{-2}	4.2×10^{-3}
Biogas	3.2×10^{-3}	6.3×10^{-4}
Biomass fuels—liquid (all fuel types in Table D-1)	1.1×10^{-3}	1.1×10^{-4}

Source: EPA Mandatory Reporting Rule, *Federal Register*, Friday, October 30, 2009
Table C-2 to Subpart C of Part 98. See www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf.

Scope 1 Mobile Combustion Emission Factors

Table D-4, Table D-5, and Table D-6 show the relevant scope 1 mobile source factors.

Table D-4: N_2O and CH_4 Emission Factors for Highway Vehicles

Fuel type	CH_4 Emission Factor (g CH_4/mile)	N_2O Emission Factor (g N_2O/mile)
Gasoline Passenger Cars		
Low emission vehicles	0.015	0.015
Tier 2	0.0036	0.0173
Tier 1	0.0429	0.0271
Tier 0	0.0647	0.0704
Oxidation catalyst	0.0504	0.1355
Non-catalyst	0.0197	0.1696
Uncontrolled	0.0197	0.178
Gasoline Light-Duty Trucks		
Low emission vehicles	0.0157	0.0148
Tier 2	0.0066	0.0163
Tier 1	0.0871	0.0452

Fuel type	CH_4 Emission Factor (g CH_4/mile)	N_2O Emission Factor (g N_2O/mile)
Tier 0	0.1056	0.0776
Oxidation catalyst	0.0639	0.1516
Non-catalyst	0.0218	0.1908
Uncontrolled	0.022	0.2024
Gasoline Heavy-Duty Trucks		
Low emission vehicles	0.032	0.0303
Tier 2	0.0134	0.0333
Tier 1	0.175	0.0655
Tier 0	0.2135	0.263
Oxidation catalyst	0.1317	0.2356
Non-catalyst	0.0473	0.4181
Uncontrolled	0.0497	0.4604
Diesel Passenger Cars		
Advanced	0.001	0.0005
Moderate	0.001	0.0005
Uncontrolled	0.0012	0.0006
Diesel Light Trucks		
Advanced	0.0015	0.001
Moderate	0.0014	0.0009
Uncontrolled	0.0017	0.0011
Diesel Heavy-Duty Trucks		
Advanced	0.0048	0.0051
Moderate	0.0048	0.0051
Uncontrolled	0.0048	0.0051
Motorcycles		
Non-Catalyst	0.0069	0.0672
Uncontrolled	0.0087	0.0899

Source: EPA Climate Leaders, Mobile Sources Guidance, Table A-1. See www.epa.gov/stateply/documents/resources/mobilesource_guidance.pdf.

Table D-5: N_2O and CH_4 Emission Factors for Alternative Fuel Vehicles

Fuel type	CH_4 Emission Factor (g CH_4/mile)	N_2O Emission Factor (g N_2O/mile)
Light Duty Vehicles		
Methanol	0.067	0.018
CNG	0.05	0.737
LPG	0.067	0.037
Ethanol	0.067	0.055
Heavy-Duty Vehicles		
Methanol	0.175	0.066
CNG	0.175	1.966
LNG	0.175	1.966
LPG	0.175	0.066
Ethanol	0.175	0.197
Buses		
Methanol	0.175	0.066
CNG	0.175	1.966
Ethanol	0.175	0.197

Source: EPA Climate Leaders, Mobile Sources Guidance, Table A-7. See www.epa.gov/stateply/documents/resources/mobilesource_guidance.pdf.

Table D-6: N_2O and CH_4 Emission Factors for Non-Highway Vehicles

Fuel type	Fuel Density (kg/gal)	CH_4 Emission Factor (g CH_4/gal fuel)	N_2O Emission Factor (g N_2O/gal fuel)
Ships and Boats			
Residual fuel oil	3.75	0.3	0.86
Diesel fuel	3.2	0.26	0.74
Gasoline	2.8	0.22	0.64
Locomotives			
Diesel Fuel	3.2	0.26	0.8
Agricultural Equipment			
Gasoline	2.8	0.22	1.26
Diesel fuel	3.2	0.26	1.44
Construction Equipment			
Gasoline	2.8	0.22	0.5
Diesel fuel	3.2	0.26	0.58
Other Non-Highway			
Snowmobiles (gasoline)	2.8	0.22	0.5
Other recreational (gasoline)	2.8	0.22	0.5
Other small utility (gasoline)	2.8	0.22	0.5
Other large utility (gasoline)	2.8	0.22	0.5
Other large utility (diesel)	3.2	0.26	0.58
Aircraft			
Jet fuel	3.08	0.31	0.27
Aviation gasoline	2.67	0.11	7.04

Source: EPA Climate Leaders, Mobile Sources Guidance, Table A-6. See www.epa.gov/stateply/documents/resources/mobilesource_guidance.pdf.

Scope 1 Fugitive F-Gas Emission Factors

Table D-7 shows scope 1 fluorinated gas fugitive emission factors.

Table D-7: Default F-Gas Emission Factors for Refrigeration/ Air Conditioning Equipment

Type of Equipment	Capacity (kg)	Installation Emission Factor *k* (% of capacity)	Operating Emission Factor *x* (% of capacity/yr)	Refrigerant Remaining at Disposal *y* (% of capacity)	Recovery Efficiency *z* (% of remaining)
Domestic refrigeration	0.05–0.5	1	0.50	80	70
Standalone commercial applications	0.2–6	3	15	80	70
Medium and large commercial refrigeration	50–2,000	3	35	100	70
Transport refrigeration	3–8	1	50	50	70
Industrial refrigeration, including food processing and cold storage	10–10,000	3	25	100	90
Chillers	10–2,000	1	15	100	95
Residential and commercial A/C, including heat pumps	0.5–100	1	10	80	80
Mobile air conditioning	0.5–1.5	0.50	20	50	50

Source: EPA, Climate Leaders Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Equipment, Table 2. See www.epa.gov/stateply/documents/resources/mfgrfg.pdf and TCR General Reporting Protocol, Version 1.1, May 2008, Table 16.3

Scope 2 Emission Factors

Scope 2 purchased electricity output emission rate factors are provided by the EPA eGRID database. The eGRID database divides the national electricity grid into 26 subregions with unique output emission rate factors on the basis of the regional electricity generation mix as shown in Table D-8. Agencies can map a facility's ZIP code to the corresponding eGRID subregion using the EPA Power Profiler website.[84] Supplemental purchased steam, hot water, and chilled water emission factors are leveraged from both eGRID and DOE 1605b Program technical guidance resources, and are provided in Table D-9 and Table D-10.

[84] EPA Power Profiler. See www.epa.gov/cleanenergy/energy-and-you/how-clean.html.

Table D-8: eGRID2007 Year 2005 Subregion Emission Rate Factors

eGRID Subregion Acronym	eGRID Subregion Name	Output Emission Rates			Fossil Fuel Output Emission Rates	Non-baseload Output Emission Rates		
		CO_2 (kg/ MWh)	CH_4 (kg/ GWh)	N_2O (kg/ GWh)	CO_2 (kg/ MWh]	CO_2 (kg/ MWh)	CH_4 (kg/ GWh)	N_2O (kg/ GWh)
AKGD	ASCC Alaska Grid	558.99	11.61	2.95	633.20	668.33	16.52	3.74
AKMS	ASCC Miscellaneous	226.28	9.41	1.85	642.85	660.93	27.43	5.38
AZNM	WECC Southwest	594.68	7.92	8.14	766.43	544.96	9.43	3.86
CAMX	WECC California	328.45	13.72	3.67	568.53	491.25	17.80	2.52
ERCT	ERCOT All	600.71	8.46	6.85	695.77	507.50	9.14	2.58
FRCC	FRCC All	598.09	20.83	7.68	635.78	614.03	21.84	5.87
HIMS	HICC Miscellaneous	687.15	142.74	21.26	769.92	759.38	153.51	23.32
HIOA	HICC Oahu	821.90	49.65	10.71	816.60	841.45	54.48	9.43
MORE	MRO East	832.21	12.51	13.77	1005.37	829.45	13.07	11.43
MROW	MRO West	826.37	12.70	13.93	1049.13	979.21	20.67	15.98
NEWE	NPCC New England	420.79	39.23	7.72	613.92	596.26	35.14	7.27
NWPP	WECC Northwest	409.25	8.68	6.76	894.92	604.93	22.35	8.50
NYCW	NPCC NYC/Westchester	369.88	16.34	2.48	642.55	691.75	25.76	4.12
NYLI	NPCC Long Island	697.08	52.35	8.21	654.56	684.85	27.36	4.89
NYUP	NPCC Upstate NY	326.95	11.26	5.08	705.03	686.79	20.55	8.35
RFCE	RFC East	516.67	13.73	8.49	758.94	812.15	18.87	11.05
RFCM	RFC Michigan	709.09	15.39	12.32	768.78	754.39	13.34	11.90
RFCW	RFC West	697.54	8.27	11.66	897.18	903.94	11.11	14.39
RMPA	WECC Rockies	854.15	10.38	13.04	936.38	733.78	10.17	9.14
SPNO	SPP North	889.46	10.80	14.56	1035.75	984.17	14.14	14.51
SPSO	SPP South	752.12	11.33	10.26	804.66	625.52	11.07	5.46
SRMV	SERC Mississippi Valley	462.54	11.03	5.31	644.77	570.21	13.38	4.45
SRMW	SERC Midwest	830.30	9.59	13.83	954.14	953.07	11.64	14.93
SRSO	SERC South	675.64	11.92	11.55	885.17	769.84	15.97	11.98
SRTV	SERC Tennessee Valley	685.12	9.09	11.63	953.17	906.44	12.81	14.90
SRVC	SERC Virginia/ Carolina	514.77	10.78	8.98	861.68	807.97	18.18	12.46
U.S.		**602.98**	**12.37**	**9.34**	**815.38**	**718.16**	**16.22**	**9.06**

Source: EPA, eGRID2007 Version 1.1 Year 2005 Summary Tables, p. 6. See www.epa.gov/RDEE/documents/egridzips/eGRID2007V1_1_year05_SummaryTables.pdf.

Table D-9: Steam/Hot Water Emission Factor

Chiller Type	CO_2 Emission Factor (Kg CO_2/MMBtu)	CH_4 Emission Factor (kg CH_4/MMBtu)	N_2O Emission Factor (kg N_2O/MMBtu)
Steam	98.19	1.9×10^{-3}	1.9×10^{-4}
Hot water	88.43	1.7×10^{-3}	1.7×10^{-4}

*Assumes a 10 percent loss during transmission.

Source: DOE, Office of Policy and International Affairs, 1605(b) Program, Technical Guidelines to the Voluntary Reporting of Greenhouse Gases (1605(b)) Program (January 2007). See www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf.

Table D-10: Chilled Water Factors

Chiller Type	Energy Source	Coefficient of Performance	Transmission Loss Adjustment*
Absorption chiller	Natural gas	0.8	1.11
Engine-driven chiller	Natural gas	1.2	1.11
Electric-driven chiller	Electricity	4.2	1.11

*Assumes a 10-percent loss during transmission.

Source: DOE, Office of Policy and International Affairs, 1605(b) Program, Technical Guidelines to the Voluntary Reporting of Greenhouse Gases (1605(b)) Program (January 2007). See www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf.

Scope 3 Emission Factors

For scope 3 emissions, or emissions not covered by the MRR or eGRID database, agencies performing advanced methodology calculations should first use the relevant emission factors from the EPA Climate Leaders Guidance and then AP 42, fifth edition.[85] Ground business travel and commuter emission factors from Climate Leaders are used in the default methodology and provided in Table D-11 and Table D-12. Agencies should refer to the EPA AP 42 website to ensure the emission factors they use are current when calculating advanced emission estimates.

[85] EPA, AP 42. See www.epa.gov/ttn/chief/ap42/index.html.

Table D-11: Ground Business and Commuter Personal Vehicle Emission Factors

Vehicle type	CO_2 Emission Factor (Kg CO_2/vehicle-mile)	CH_4 Emission Factor (kg CH_4/vehicle-mile)	N_2O Emission Factor (kg N_2O/vehicle-mile)
Passenger car	0.364	0.031×10^{-3}	0.032×10^{-3}
Light-duty truck/van/SUV	0.519	0.036×10^{-3}	0.047×10^{-3}
Motorcycle	0.167	0.070×10^{-3}	0.007×10^{-3}

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport. See www.epa.gov/stateply/documents/resources/commute_travel_product.pdf.

Table D-12: Commuter & Mass Transit Emission Factors

Vehicle type	CO_2 Emission Factor (kg CO_2/passenger-mile)	CH_4 Emission Factor (kg CH_4/passenger-mile)	N_2O Emission Factor (kg N_2O/passenger-mile)
Car pool	0.182	0.016×10^{-3}	0.016×10^{-3}
Van pool	0.130	0.009×10^{-3}	0.012×10^{-3}
Bus	0.107	0.0006×10^{-3}	0.0005×10^{-3}
Transit rail	0.163	0.004×10^{-3}	0.002×10^{-3}
Commuter rail	0.172	0.002×10^{-3}	0.001×10^{-3}
Intercity rail	0.185	0.002×10^{-3}	0.001×10^{-3}

Source: EPA Climate Leaders, Optional Emissions from Commuting, Business Travel and Product Transport. See: www.epa.gov/stateply/documents/resources/commute_travel_product.pdf.

Global Warming Potentials

Table D-13: Global Warming Potentials

Name	CAS No.	Chemical formula	Global warming potential (100 yr.)
Carbon dioxide	124–38–9	CO_2	1
Methane	74–82–8	CH_4	21
Nitrous oxide	10024–97–2	N_2O	310
HFC–23	75–46–7	CHF_3	11,700
HFC–32	75–10–5	CH_2F_2	650
HFC–41	593–53–3	CH_3F	150
HFC–125	354–33–6	C_2HF_5	2,800
HFC–134	359–35–3	$C_2H_2F_4$	1,000
HFC–134a	811–97–2	CH_2FCF_3	1,300
HFC–143	430–66–0	$C_2H_3F_3$	300
HFC–143a	420–46–2	$C_2H_3F_3$	3,800
HFC–152	624–72–6	CH_2FCH_2F	53
HFC–152a	75–37–6	CH_3CHF_2	140
HFC–161	353–36–6	CH_3CH_2F	12
HFC–227ea	431–89–0	C_3HF_7	2,900
HFC–236cb	677–56–5	$CH_2FCF_2CF_3$	1,340
HFC–236ea	431–63–0	CHF_2CHFCF_3	1,370
HFC–236fa	690–39–1	$C_3H_2F_6$	6,300
HFC–245ca	679–86–7	$C_3H_3F_5$	560
HFC–245fa	460–73–1	$CHF_2CH_2CF_3$	1,030
HFC–365mfc	406–58–6	$CH_3CF_2CH_2CF_3$	794
HFC–43–10mee	138495–42–8	$CF_3CFHCFHCF_2CF_3$	1,300
Sulfur hexafluoride	2551–62–4	SF_6	23,900
Trifluoromethyl sulphur pentafluoride	373–80–8	SF_5CF_3	17,700
Nitrogen trifluoride	7783–54–2	NF_3	17,200
PFC–14 (Perfluoromethane)	75–73–0	CF_4	6,500
PFC–116 (Perfluoroethane)	76–16–4	C_2F_6	9,200
PFC–218 (Perfluoropropane)	76–19–7	C_3F_8	7,000
Perfluorocyclopropane	931–91–9	$C\text{-}C_3F_6$	17,340
PFC–3–1–10 (Perfluorobutane)	355–25–9	C_4F_{10}	7,000
Perfluorocyclobutane	115–25–3	$C\text{-}C_4F_8$	8,700

Name	CAS No.	Chemical formula	Global warming potential (100 yr.)
PFC–4–1–12 (Perfluoropentane)	678–26–2	C_5F_{12}	7,500
PFC–5–1–14 (Perfluorohexane)	355–42–0	C_6F_{14}	7,400
PFC–9–1–18	306–94–5	$C_{10}F_{18}$	7,500
HCFE–235da2 (Isoflurane)	26675–46–7	$CHF_{2O}CHC_lCF_3$	350
HFE–43–10pccc (H–Galden 1040x)	E1730133	$CHF_2OCF_2OC_2F_4OCHF_2$	1,870
HFE–125	3822–68–2	CHF_2OCF_3	14,900
HFE–134	1691–17–4	CHF_2OCHF_2	6,320
HFE–143a	421–14–7	CH_3OCF_3	756
HFE–227ea	2356–62–9	$CF_3CHFOCF_3$	1,540
HFE–236ca12 (HG–10)	78522–47–1	$CHF_2OCF_2OCHF_2$	2,800
HFE–236ea2 (Desflurane)	57041–67–5	$CHF_2OCHFCF_3$	989
HFE–236fa	20193–67–3	$CF_3CH_2OCF_3$	487
HFE–245cb2	22410–44–2	$CH_3OCF_2CF_3$	708
HFE–245fa1	84011–15–4	$CHF_2CH_2OCF_3$	286
HFE–245fa2	1885–48–9	$CHF_2OCH_2CF_3$	659
HFE–254cb2	425–88–7	$CH_3OCF_2CHF_2$	359
HFE–263fb2	460–43–5	$CF_3CH_2OCH_3$	11
HFE–329mcc2	67490–36–2	$CF_3CF_2OCF_2CHF_2$	919
HFE–338mcf2	156053–88–2	$CF_3CF_2OCH_2CF_3$	552
HFE–338pcc13 (HG–01)	188690–78–0	$CHF_2OCF_2CF_2OCHF_2$	1,500
HFE–347mcc3	28523–86–6	$CH_3OCF_2CF_2CF_3$	575
HFE–347mcf2	E1730135	$CF_3CF_2OCH_2CHF_2$	374
HFE–347pcf2	406–78–0	$CHF_2CF_2OCH_2CF_3$	580
HFE–356mec3	382–34–3	$CH_3OCF_2CHFCF_3$	101
HFE–356pcc3	160620–20–2	$CH_3OCF_2CF_2CHF_2$	110
HFE–356pcf2	E1730137	$CHF_2CH_2OCF_2CHF_2$	265
HFE–356pcf3	35042–99–0	$CHF_2OCH_2CF_2CHF_2$	502
HFE–365mcf3	378–16–5	$CF_3CF_2CH_2OCH_3$	11
HFE–374pc2	512–51–6	$CH_3CH_2OCF_2CHF_2$	557
HFE–449sl (HFE–7100) Chemical blend	163702–07–6 163702–08–7	$C_4F_9OCH_3$ $(CF_3)_2CFCF_2OCH_3$	297
HFE–569sf2 (HFE–7200) Chemical blend	163702–05–4 163702–06–5	$C_4F_9OC_2H_5$ $(CF_3)_2CFCF_2OC_2H_5$	59
Sevoflurane	28523–86–6	$CH_2FOCH(CF_3)_2$	345

Name	CAS No.	Chemical formula	Global warming potential (100 yr.)
HFE–356mm1	13171–18–1	$(CF_3)_2CHOCH_3$	27
HFE–338mmz1	26103–08–2	$CHF_2OCH(CF_3)_2$	380
(Octafluorotetramethylene) hydroxymethyl group	NA	$X\text{-}(CF_2)_4CH(OH)\text{-}X$	73
HFE–347mmy1	22052–84–2	$CH_3OCF(CF_3)_2$	343
Bis(trifluoromethyl)-methanol	920–66–1	$(CF_3)_2CHOH$	195
2,2,3,3,3-pentafluoropropanol	422–05–9	$CF_3CF_2CH_2OH$	42
PFPMIE	NA	$CF_3OCF(CF_3)CF_2OCF_2OCF_3$	10,300

Source: EPA Mandatory Reporting Rule, Federal Register, Friday, October 30, 2009
Table A-1 to Subpart A of Part 98. See www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf.

Conversion Factors

Table D-14: General Conversion Factors

To convert from	To	Multiply by
Weight		
Kilograms (kg)	Pounds (lb)	2.20462
Pounds (lb)	Kilograms (kg)	0.45359
Pounds (lb)	Metric tons	4.53592×10^{-4}
Short tons	Pounds (lb)	2,000
Short tons	Metric tons	0.90718
Metric tons (MT)	Short tons	1.10231
Metric tons (MT)	Kilograms (kg)	1,000
Million MT CO_2e (MMT CO_2e)	MT CO_2e (MT CO_2e)	1,000,000
Metric tons (MT)	Tons	1
Volume		
Cubic meters (m^3)	Cubic feet (cu ft or ft^3)	35.31467
Cubic feet (cu ft or ft^3)	Cubic meters (m^3)	0.028317
Gallons (liquid, U.S.)	Liters (l)	3.78541
Liters (l)	Gallons (liquid, U.S.)	0.26417
Barrels of Liquid Fuel (bbl)	Cubic meters (m^3)	0.15891
Cubic meters (m3)	Barrels of Liquid Fuel (bbl)	6.289
Barrels of Liquid Fuel (bbl)	Gallons (liquid, U.S.)	42
Gallons (liquid, U.S.)	Barrels of liquid fuel (bbl)	0.023810

To convert from	To	Multiply by
Gallons (liquid, U.S.)	Cubic meters (m^3)	0.0037854
Liters (l)	Cubic meters (m^3)	0.001
Distance		
Feet (ft)	Meters (m)	0.3048
Meters (m)	Feet (ft)	3.28084
Miles (mi)	Kilometers (km)	1.60934
Kilometers (km)	Miles (mi)	0.62137
Area		
Square feet (ft^2)	Acres	2.29568×10^{-5}
Square meters (m^2)	Acres	2.47105×10^{-4}
Square miles (mi^2)	Square kilometers (km2)	2.58999
Temperature		
Degrees Celsius (°C)	Degrees Fahrenheit (°F)	°C = (5⁄9) × (°F – 32)
Degrees Fahrenheit (°F)	Degrees Celsius (°C)	°F = (9⁄5) × °C + 32
Degrees Celsius (°C)	Kelvin (K)	K = °C + 273.15
Kelvin (K)	Degrees Rankine (°R)	1.8
Energy		
Joules	Btu	9.47817×10^{-4}
Btu	MMBtu	1×10^{-6}
Btu	BBtu	1×10^{-9}
Ton hour	Btu	1.2×10^{1}
Ton hour	MMBtu	1.2×10^{-2}
MWh	MMBtu	3.413
Pressure		
Pascals (Pa)	Inches of mercury (in Hg)	2.95334×10^{-4}
Inches of mercury (in Hg)	Pounds per square inch (psi)	0.49110
Pounds per square inch (psi)	Inches of mercury (in Hg)	2.03625

Source 1: EPA Mandatory Reporting Rule, Federal Register, Friday, October 30, 2009
Table A-2 to Subpart A of Part 98. See www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf.
Source 2: DOE, Office of Policy and International Affairs, 1605(b) Program, Technical Guidelines to the Voluntary Reporting of Greenhouse Gases (1605(b)) Program (January 2007). See www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf.

Table D-15: GGE Conversion Factors

Alternative Fuel	Natural Units	Gasoline Gallon Equivalent (GGE)
B100	Gallons	101.5% (gal x 1.015 = GGE)
B20	Gallons	112.6% (gal x 1.126 = GGE)
CNG	Gallons at 2,400 psi	18% (gal x 0.18 = GGE)
CNG	Gallons at 3,000 psi	22.5% (gal x 0.225 = GGE)
CNG	Gallons at 3,600 psi	27% (gal x 0.27 = GGE)
CNG	Hundred cubic feet	83% (ccf x 0.83 = GGE)
Diesel	Gallons	114.7% (gal x 1.147 = GGE)
Diesel—emergency, special purpose, and military	Gallons	114.7% (gal x 1.147 = GGE)
Diesel—law enforcement vehicles	Gallons	114.7% (gal x 1.147 = GGE)
E-85	Gallons	72% (gal x 0.72 = GGE)
Electric	kWh	3% (kWh x 0.03 = GGE)
Gasoline	Gallons	No conversion needed
Gasoline—emergency, special purpose, and military	Gallons	No conversion needed
Gasoline—law enforcement vehicles	Gallons	No conversion needed
LNG	Gallons @ 14.7 psi and –234 degrees F	66% (gal x 0.66 = GGE)
LPG	Gallons	74% (gal x 0.74 = GGE)
M-85	Gallons	57% (gal x 0.57 = GGE)

Source: DOE and GSA, Federal Automotive Statistical Tool Program. See: https://fastweb.inel.gov/